

BakerHicks.
One Warwick Technology Park
Gallows Hill
Warwick, CV34 6YL

T. (0)1926 567800
bakerhicks.com

GROUND INVESTIGATION REPORT: MARGAM SUBSTATION

Margam Connection

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1. Information

1.1. Scope and Objectives of the Report

This Ground Investigation Report (GIR) summarises data from a recent Ground Investigation (GI) carried out at the proposed Margam Substation site between 23rd July and 20th September 2024. This report has been written based on the Geotechnics final factual report (Ref [1]). The interpretation outlined in this report will assist with the detailed design phase of this project.

This report was originally issued by BakerHicks to the Client in January and February 2025, when the proposals at that time comprised two options for the location of the substation. Revision P03 of this report acknowledges the finalisation of the site location. It is understood that this report is to be submitted in support of a future Planning Application.

This report is an Interpretative Ground Investigation Report (GIR) and generally follows the requirements of BS EN 1997 – Eurocode 7 (Ref. [2], [3]) and BS 10175:2011+A2:2017 – Investigation of Potentially Contaminated Sites (Ref [4]).

Existing geotechnical and land quality data for the scheme is summarised in Section 2 of this report using freely available online information and the previously completed Geotechnical Desk Study (Ref. [5]) which included a review of an Envirocheck Report (Ref. [6]) for the project.

This report is intended to:

- Present appropriate geotechnical information, geological features and other relevant data;
- Present an evaluation of the information, and stating assumptions made in the interpretation of the data;
- State known limitations of the results, as appropriate;
- Present design values and recommendations in terms of foundations, excavations, and pavements and the management of site won materials;
- Provide a geo-environmental screen of the site; and
- Present a geotechnical risk register for the proposed works.

This report considers the proposed Margam Substation only. The proposed high voltage underground cable route and Port Talbot Substation are covered in separate reports.

1.2. Summary of Proposed Works

The site is proposed to be developed into a National Grid Electricity Transmission (NGET) substation. A summary of the proposed works for this project are expected to comprise construction of the following components:

- GIS Hall;
- Overhead Line Gentries;
- MSCDN Compound;
- Busbars connecting existing;
- Amenity Building;
- Flood wall;
- Fencing;
- Drainage and attenuation pond; and
- Pavement areas and walkways.

The proposed site plan is shown on the Margam GIS Hall – Proposed Site Plan drawing (ref: MARPT-BHK-01-ZZ-DG-A-130023 Rev P05, dated July 2025), a copy of which is included in Appendix E.

1.3. Site Location and Description

The proposed Margam Substation (hereby referred to as “the site”) is approximately 1.65 ha in size and is located in the Port Talbot suburb of Margam in the Welsh county borough of Neath Port Talbot, South Wales. The National Grid Reference for the centre of the site is SS 78580 86373. A site location plan is included as Figure 1.1 and the full red line site boundary is shown as Figure 1.2.

The site currently comprises undeveloped low-lying marshland and woodland with multiple small ditches which discharge into the Upper Mother Ditch. The existing Margam substation is immediately adjacent on the western boundary of the site. The existing TATA steel plant is present to the west of the site, beyond the Great Western Main Line, which runs beyond the western extent of the site, running in an approximate north south orientation.



Figure 1.1 Site Location Plan

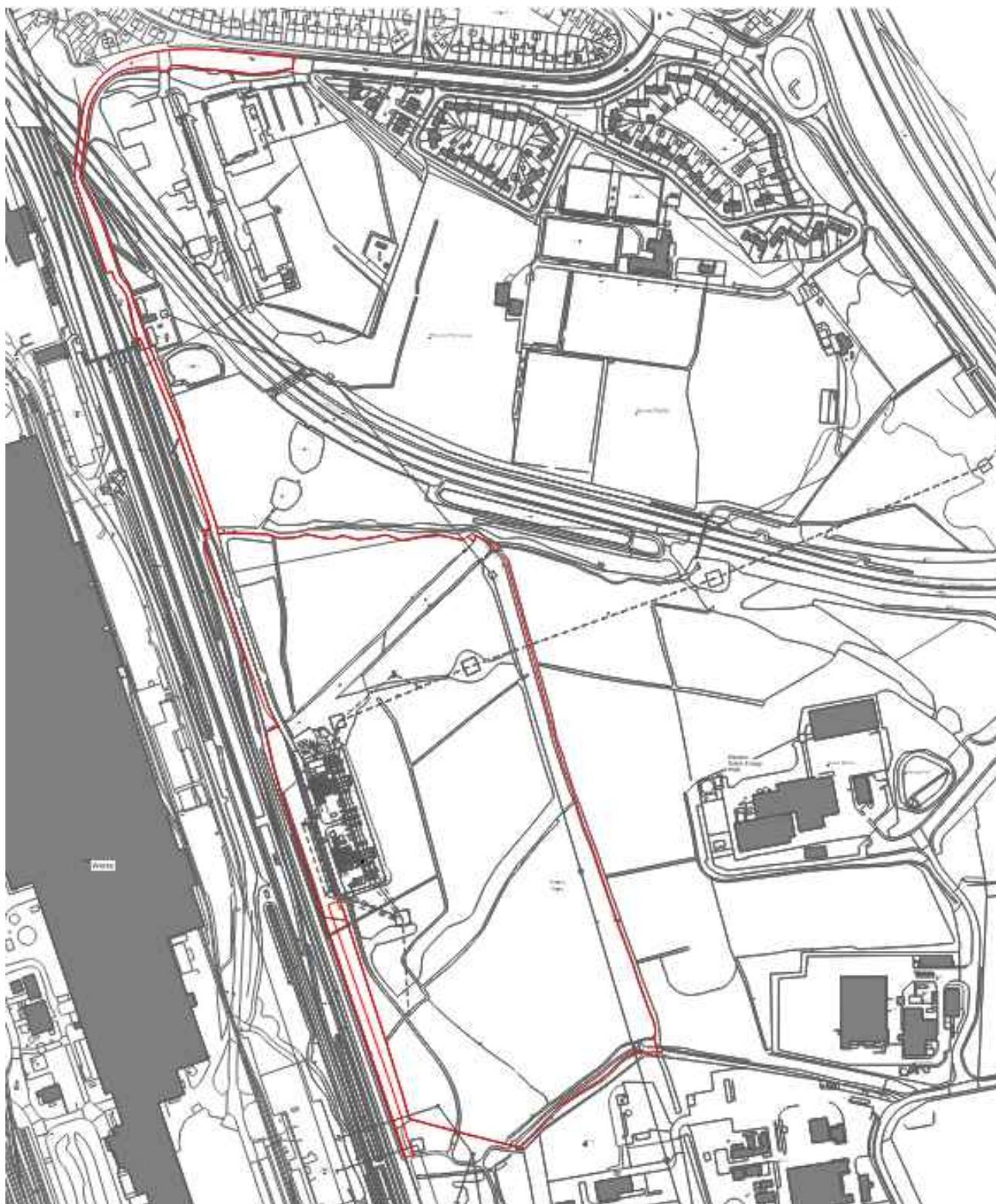


Figure 1.2 Red Line Boundary

1.4. Geotechnical Category

Eurocode 7 states “in order to establish minimum requirements for the extent and content of geotechnical investigations, calculations and construction control checks, the complexity of each geotechnical design shall be identified together with associated risks”.

To determine the design requirements, the following three categories are utilised:

- Category 1 – assigned to small and relatively simple structures.
- Category 2 – assigned to conventional types of structures and foundations with no exceptional risk or difficult ground or loading conditions; and
- Category 3 – assigned to complex ground conditions and large complex structures.

This scheme falls into the requirements of a Category 2 scheme, whose designs should use quantitative geotechnical data and analysis to ensure that the fundamental requirements are satisfied with this data being supported by routine procedures for field and laboratory testing.

1.5. Assumptions and Limitations

BakerHicks is responsible for selecting and summarising the data supplied by the client or other parties but cannot be held responsible for any mistakes or inaccuracies or the completeness of third-party data on which it has relied. As with any point data, ground conditions can only be inferred between test locations and as such localised conditions on site may vary between point locations and conditions may be encountered that have not been identified during the investigations.

This Ground Investigation Report has been prepared solely for Laing O’Rourke in connection with the proposed development. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party. This report has been prepared from the Phase 1 (i.e., National Grid area) ground investigation, which was designed based on the layout site layout at that time. Should the recommendations of findings be used for other purposes they will need to be revisited to confirm they remain valid and suitable change in purpose.

This report and the ground investigation has been undertaken to support the detailed design at the site. The design of the ground investigation was originally undertaken for National Grid (NG) for the purposes of a FEED study which covered 2no. substation options: Option 2 & Option 4. Due to wider programme requirements the FEED study was not complete, and the project moved straight onto the detailed design stage. In line with this, the proposed FEED GI was revised to capture the GI required to enable the detailed design of Margam Substation Option 4, however without the initial FEED GI to identify ground conditions the detailed design GI could not be as targeted and therefore unforeseen geotechnical risks could remain. The proposed GI specification was discussed and agreed with Laing O’Rourke. Aspects relating to the previous site layouts are captured in earlier revisions of this report, with this version focused on the proposed site layout shown in Figure 1.3.

Where appropriate, this report only identifies potential asbestos occurrences, however, detailed advice should be sought from a specialist contractor on specialist measures for dealing with it safely.

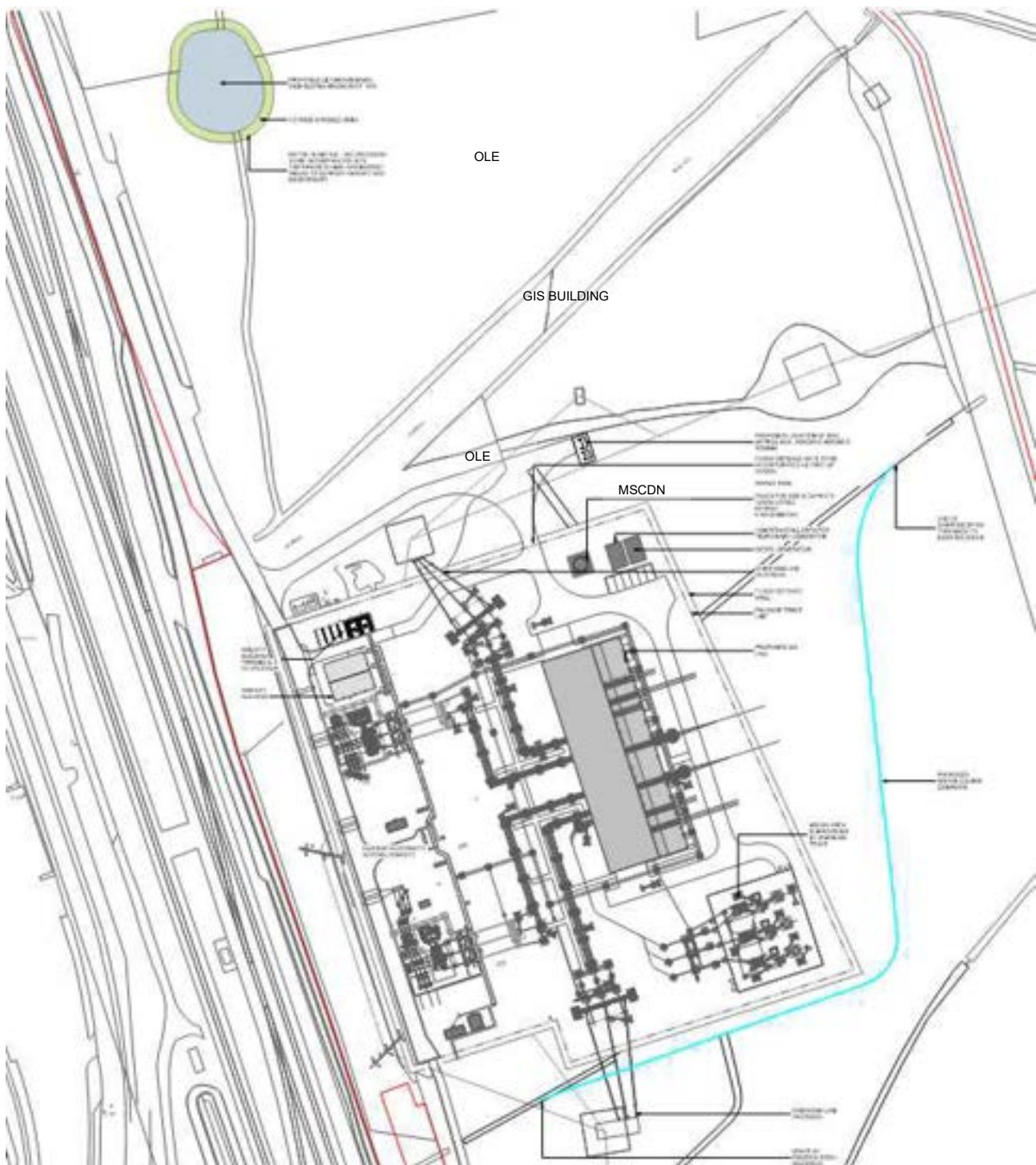


Figure 1.3. Proposed Margam Site Layout

2. Existing Information

A summary of desk study information relative to this GIR, as presented in the Geotechnical Desk Study Report (Ref. [7]) is summarised below. The Geotechnical Desk Study was prepared for the wider scheme which includes the development of the Port Talbot Substation and High Voltage Cable Route. Reference should be made to the Geotechnical Desk Study report for further detail.

2.1.1. Conceptual Site Model

The report identified a series of potentially active pollution linkage within the Preliminary Conceptual Site Model for the scheme which were grouped together in the initial CSM with onsite sources separated by study area and off-site sources grouped for the scheme as a whole.

It is highlighted that the Tata site is more local to the majority of the high-risk sources in the area. As a result, Table 2.1 below breaks down the source pathway receptor linkage from the report into a site specific CSM for the Margam Option 4 site.

Table 2.1. Conceptual Site Model

Potential Source	Potential Pathway	Potential Receptor	Probability	Consequence	Risk (without mitigation)
Onsite Sources	-				
No onsite sources identified					
Offsite Sources					
Existing Margam Substation adjacent to the site, including associated tanks and infrastructure. (Off Site)	Lateral Migration	Future Site Users	Medium	Moderate	Moderate
Current and former uses associated with historic railway line dating from 1876 to present day (off site 80m west)	Lateral Migration	Future Site Users	Low to Medium	Moderate	Moderate/low to Moderate
	Inhalation of Fibres	Future Site Users	Low	Severe	Moderate
Former and current site uses associated with steel works dating from 1950 to present day (off site 205m west)	Lateral Migration	Future Site Users	Low to Medium	Moderate	Moderate/low to Moderate
	Inhalation of Fibres	Future Site Users	Low	Severe	Moderate
	Migration Into Confined Spaces	Future Site Users	Low	Severe	Moderate
Historic infilled ponds north of the site and series of drainage ditches within 250m (Off Site)	Migration into confined spaces	Future Site Users	Low	Severe	Moderate
Contemporary Trade Entry within 300m of the site (offsite)	Lateral Migration	Future site users	Medium	Moderate	Moderate

The following sources were deemed to be too far distant to have a credible SPR linkage for this part of the site due to being located further than 250m from the site boundary;

- Former Abbot Pit and Morfa Colliery 60-160m north of TATA substation. Approximately 530m northwest of the site boundary.
- Power station west of proposed Port Talbot Substation site. Approximately 1.04km west of the Margam Substation site boundary.

Additionally, the historic ponds have been lowered in risk likelihood from medium to low due to the smaller nature of the sources located within the 250m radius around the site.

Based on the potential pollution linkages, a preliminary investigation was proposed to determine if pollution linkages were active or inactive.

2.2. Topography

A review of the topography was undertaken using freely available online resources including LiDAR data from the Welsh Government (Ref. [8]); Google Earth (Ref. [9]); and OS maps gathered within the Envirocheck Report (Ref [6]).

The area forming the proposed site is relatively flat, with the available LiDAR showing that the site is approximately 3m AOD. It was noted that there is an approximate 1m rise in ground level on the western boundary of the site likely associated with the existing Margam Substation. The OS and aerial mapping shows 3no. small ditches within the site boundary. One ditch runs approximately north/south splitting the site in the centre, another ditch splits from this at the southern boundary of the site running east. Another ditch feeds into this central ditch from the west towards the northeast boundary of the site. Aerial mapping shows much of the site is grassland/marshland, however mature trees are present particularly on the boundary of the main ditch running through the site.

2.3. Geology and Hydrogeology

The following sources of information have been reviewed and are discussed below:

The following sources of information have been reviewed and discussed below.

- British Geological Survey, 1:50,000 New Series, Sheet 247 Swansea, Bedrock, 2011 (Ref. [10])
- British Geological Survey, 1:50,000 New Series, Sheet 247 Swansea, Bedrock and Superficial, 2011 (Ref. [11]).
- British Geological Survey, 1:10,000 Series, Sheet SS78NE, Solid and Drift, 1970 (Ref. [12]).
- British Geological Survey GeoIndex (Onshore) (Ref. [13]).
- Envirocheck Report (Ref. [6])

Information is summarised in Table 2.2 with further commentary below.

Table 2.2. Summary of Published Geology.

Geological Unit	Formation Name	Description	Aquifer Classification
Artificial Ground	Not Recorded	-	-
Superficial	Tidal Flat Deposits	Unconsolidated sediment, mainly mud and/or sand.	Secondary Undifferentiated Aquifer
Bedrock	South Wales Middle Coal Measures Formation	Coal bearing mudstones/siltstones, with seatearths and minor sandstones.	Secondary A Aquifer

The site is not recorded as being within a source protection zone.

2.3.1. Artificial Geology

Published BGS geological mapping does not record the presence of Made Ground on the site.

2.3.2. Superficial Geology

BGS maps indicate the site is underlain by Tidal Flat Deposits. The Envirocheck report (Ref. [6]) records the following ground stability hazards relating to superficial geology:

- Moderate Risk from Compressible Ground.
- Moderate Risk from Running Sands.
- Very Low Risk from Landslides.
- Very Low Risk from Shrink/Swell Clays.

2.3.3. Solid Geology

The solid geology is mapped as the South Wales Middle Coal Measures Formation. The Envirocheck report (Ref. [6]) indicates that there is no hazard of ground dissolution or collapsible ground.

A thrust fault is recorded approximately 20m north of the site which runs approximately east-west. The southern side is recorded as downthrown. Due to the movement of the thrust fault many of the recorded coal seams are likely to be present at shallower depths on the north side of the fault. The Margam Substation is on the south side of the fault.

Due to the site lying within a coal mining reporting area a Coal Mining Risk Assessment was undertaken (Ref. [14]). The BGS 1:10,000 geological map (Ref. [12]) shows that the shallowest coal seam beneath the site is the 2ft 9 seam which sub-crops south of the site and is shown to be dipping towards the north. However, as discussed in the CMRA, the shallowest recorded worked seam is the Five Foot seam which is present at a depth of at least 85m beneath the site with a recorded worked thickness of 3.3m. CIRIA C785D (Ref. [15]) suggests that a criterion of ten times worked seam thickness provides reasonable assurance against surface subsidence. Using this criterion, 33m of rock cover is required to mitigate surface subsidence. Therefore, the worked Five Foot seam at 85m depth is unlikely to be within influencing depth of the proposed development. The Coal Mining Risk Assessment concluded that there is a moderate risk of potential unrecorded shallow workings across the site. Therefore, the GI was also specified to investigate this to help mitigate this risk. This is discussed further in Section 9.7.

2.3.4. Historical Ground Investigation

A review of BGS GeoIndex (Ref [13]) concluded there were no boreholes within 100m of the site.

A previous GI was undertaken by Jacobs in 2009 (Ref. [16]) within an area of land approximately 40m north of the site. The GI comprised 8no. Trial pits and 5no. boreholes.

The ground investigation encountered superficial material comprising Tidal Flat deposits including Peat underlain by granular and cohesive Glacial deposits. The superficial deposits were underlain by bedrock of the Coal Measures formation with rockhead varying from 12.7m to 15m depth below ground level.

Made Ground was not encountered during the GI. A geo-environmental assessment was undertaken by Jacobs which concluded that the soil samples showed no sign of significant contamination although some of the groundwater results exceeded EQS values for Lead, Zinc and Ammonia.

3. Ground Investigation

A ground investigation (GI) was undertaken by Geotechnics Ltd between August and September 2024 to support the detailed design. The aims of the GI were as follows:

- To investigate the nature and depth of any superficial deposits and bedrock geology;
- To collect samples for geotechnical testing to provide indicative material properties of the strata at the site;
- To collect samples for geo-environmental testing to determine the presence and level of contamination at the site;
- To understand the thermal resistivity and pH of the ground;
- To install gas and groundwater monitoring installations and provide information on the gas and groundwater conditions of the site.
- To investigate the risk from coal mining identified as part of the Coal Mining Risk Assessment (Ref. [14]).

3.1. Scope of the Completed Ground Investigation

The scope of the ground investigation was revised on 5no. occasions. The original GI scope was designed for the purpose of a FEED study. The GI scope was developed for the entire scheme which included the proposed Port Talbot Substation and High Voltage Cable Route. Revisions were made to satisfy the following:

- Inclusion of additional substation options at FEED;
- Revision of GI phasing from 1no. phase to 4no. phases due to land access constraints;
- Following receipt of a detailed UXO Assessment which outlined a low risk of UXO;
- To update the FEED GI specification to a detailed design GI specification.
- To update the specification based on additional requirements from LOR including the rising head permeability tests and sampling for soil stabilisation testing.

Soil stabilisation testing was requested by LOR which BHK commissioned with Deep Soil Mixing Ltd based on specification provided by VolkerFitzpatrick Ltd. The findings of this testing are not discussed in this report.

The scope of the GI undertaken is detailed in revision P05 of the GI Specification (Ref. [17]). It should be noted that this specification covers 4no. Phases of GI within different land areas:

- National Grid Land
- BOC Land
- TATA Operational Land
- TATA Non-Operational Land

The GI was specified to inform design on multiple elements of the project including the Margam Substation.

The factual records from the ground investigation are presented in the Geotechnics Final Factual Ground Investigation Report (Ref. [1]), included in Appendix A. It should be noted that for the geotechnical assessment contained within this report only the data from exploratory positions within the proposed Margam Substation boundary (Figure 1.3) has been included. A summary of the information used is presented within Table 3.1. For the Geoenvironmental assessment all data within the Phase 1 GI has been considered.

Table 3.1: Summary of the ground investigation works within Margam Substation used in the geotechnical assessment.

Exploratory Hole Type	Quantity and ID		Termination depth (m bgl)
Cable percussive boreholes	5	BH105, BH106, BH108, BH110, BH111	12.20-15.00
Cable percussive with rotary core follow on	2	BH107, BH109	49.50
Trial Pits	11	TP105, TP105A, TP105B, TP106, TP108-TP114	0.50-3.00
Dynamic Cone Penetrometer (DCP)	10	DCP105, DCP105A, DCP106, DCP108 – DCP114	0.49-2.22
Soakaway Tests	3 ^[1]	TP109, TP110 & TP112	1.50

[1] Scheduled but not complete due to high groundwater level.

The completed GI varied from the specification due to encountered site conditions. This included:

- Due to the shallow groundwater and artesian water at the site only 1no. install was successfully installed.
- TP105 being terminated at 0.50m bgl due to being unable to advance through the made ground with a toothless bucket. The trial pit was moved and undertaken as TP105A.
- Addition of TP105B to collect environmental samples that weren't collected in TP105.
- Cable Percussive boreholes: BH106, BH108, BH110 & BH111 being terminated shallower than scheduled 15m bgl due to encountering rockhead slightly shallower than anticipated.

3.2. Laboratory Investigation

3.2.1. Geotechnical Testing

The laboratory tests, where appropriate, conform to BS 1377-2 (Ref. [18]), BS EN ISO 17892-1 (Ref. [19]), BS EN ISO 17892-3 (Ref. [20]), and BS EN ISO 17892-4 (Ref. [21]).

Presented in Table 3.2 is a summary of the laboratory testing undertaken to assess the classification, strength and reusability of the soil samples. It should be noted that since the completion of the GI works additional testing has been scheduled the results of which are outstanding but will be included in final revision of this report. Any variation to the scheduled testing including non-conformance report (NCR) notes is shown within the comments in the table below.

Table 3.2: Summary of in-situ and laboratory geotechnical testing.

Category	Test	Scheduled	Completed	Comments
Laboratory Classification Tests	Particle Size Distribution BS1377 (Wet Sieve)	19	19	Additional test complete on TP106 0.3m
	Particle Size Distribution BS1377 (Sedimentation)	8	7	Additional test complete on BH106 7.7m. 2no samples note tests as <15% fines.
	Moisture Content	42	48	

Category	Test	Scheduled	Completed	Comments
	Atterberg Limits	32	32	
Laboratory Strength Tests	Quick Undrained Triaxial Tests	6	4	2no. NCR sample too gravelly. 1no. Shear Box scheduled instead.
	Shear Box Tests	1	1	
	Point Load Tests	7	14	
	UCS Tests	12	7	11no. Tests replaced by Point Load tests due to sample size
Laboratory Consolidation Test	Oedometer Tests	9	3	5no NCR sample too gravelly or too wet.
Laboratory Compaction Test	Compaction 2.5kg	3	1	2no. NCR sample too gravelly.
	Remoulded California Bearing Ratio	3	3	
Laboratory Permeability Tests	Constant Head in a Permeameter	3	3	
	Constant Head in a Triaxial Cell	6	6	
Laboratory Chemical Tests	BRE Suite D	17	17	
	Organic Test	6	6	
Laboratory Thermal Tests	Thermal Resistivity Tests	7	7	

3.2.2. Soil / Water Contaminant Analysis

An assessment of a broad suite of determinants has been undertaken. Determinants include metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs) and asbestos. The following tests were performed across the Phase 1 GI to determine the presence and level of contamination of the soil samples:

- 42 No. Soil Suite E (ICE 3rd Edition (Ref [22]));
- 6 No. Soil Leachate Suite;
- 10 No. Soil WAC Suites;
- 1 No. Water Suite F (ICE 3rd Edition (Ref [22]));

4. Ground Summary

4.1. Introduction

The following section presents a summary of the reported ground conditions at the site based on the ground investigation carried out by Geotechnics Ltd.

The investigation confirmed that the site is underlain by Tidal Flat Deposits and ultimately the solid geology of the South Wales Middle Coal Measures Formation. However, the investigation found that there is a significant thickness of peat deposits within the Tidal Flat Deposits. The investigation also recorded that the Tidal Flat Deposits are underlain by both cohesive and granular glacial deposits before encountering the South Wales Middle Coal Measures.

Made ground is present in TP05, TP05A & TP05B up to a depth of 2.30m bgl. Due to the Made Ground being encountered in 3no. trial pits within close proximity to one another in an area of the site where the only development proposed is a road with no load bearing structures or earthworks, this material has not been considered within the ground model for the site as it is unlikely to be beneath any major proposed major structures. The access road design needs to consider the CBR values from the DCP tests undertaken within the made ground. Additional confirmatory CBR testing should be undertaken during construction if required.

A high-level summary of the encountered geology is presented in Table 4.1.

Table 4.1: Summary ground model.

Strata	Depth of top (m bgl)	Elevation of top (m AOD)	Thickness range (m)
Topsoil	0.00	2.95 to 3.15	0.20 to 0.70
Tidal Flat Deposits - Cohesive (TFD)	0.20 to 0.70	2.95 to 2.27	0.60 to 4.50
Tidal Flat Deposit – Peat (Peat)	0.20 to 3.60	2.75 to -0.45	0.50 to 4.70
Cohesive Glacial Deposits	4.30 to 8.60	-1.25 to -5.56	0.50 to 6.30
Granular Glacial Deposits	4.70 to 5.80	-1.55 to -2.77	0.20 to 3.10
Weathered Coal Measures Formation ^[1]	11.90 to 13.30	-8.83 to -10.26	1.00 to 5.70
Coal Measures Formation ^[2]	14.30 to 18.80	-11.26 to -15.85	35.20 +

^[1] Thickness proven in BH107 & BH109 only.

^[2] Thickness not proven.

Factual descriptions for the encountered geological units are provided in Sections 4.2 to 4.7. These descriptions are as provided within the appended Geotechnics Ltd Factual Report (Appendix A).

4.2. Topsoil

Topsoil was encountered across the site in all exploratory positions except TP05, TP05A and TP05B from ground level to depths between 0.20m and 0.70m bgl, this was typically described as:

- Grass over very soft dark brown slightly sandy organic clay with occasional rootlets and roots.
- Soft dark brown slightly sandy organic clay with many roots.

4.3. Made Ground

Made Ground was encountered within TP05, TP05A and TP05B from ground level to depths between 0.50m and 2.30m bgl. The depth of made ground was not proven in these trial pits. This was encountered as granular and cohesive material and described as:

- Light brown clay bound sandy gravel with occasional metal girders and a high cobble content of concrete and slag. Gravel is angular to subangular fine to coarse concrete and slag.
- Black slightly clayey gravelly sand with some ash. Gravel is angular to subangular fine to coarse brick and coal.
- Soft dark grey slightly sandy gravelly clay with occasional roots (up to 50mm in diameter). Gravel is angular to subangular fine to coarse slag.

The presence of made ground was limited to 3no. trial pits which were in close proximity to each other. These trial pits were located in the northern part of the site where a road is proposed. The presence of this made ground is likely to be associated with the existing Margam Substation part of the road formation to the existing OHL gantries.

4.4. Tidal Flat Deposits - Cohesive

The Cohesive Tidal Flat Deposits (TFD-C) were encountered in all exploratory positions apart from TP105, TP105A and TP105B beneath the topsoil to depths between 1.10m and 5.40m bgl. It was typically described as:

- Very soft to soft blueish grey slightly sandy CLAY.
- Very soft to soft blueish grey slightly sandy CLAY with occasional roots or pockets of peat between 15mm and 100mm in size.

4.5. Tidal Flat Deposits - Peat

A layer of peat was encountered which is geologically part of the Tidal Flat Deposits but has been separated out as part of the interpretation due to its geotechnical properties.

The peat layer was encountered in all exploratory positions apart from BH105, TP105, TP105A and TP105B either below or within the cohesive element of the Tidal Flat Deposits. The peat extended to proven depths between 3.50m and 5.80m bgl. It was typically described as:

- Spongy dark brown fibrous & pseudo fibrous PEAT, occasional roots and wood fragments also recorded.

4.6. Glacial Till Deposits – Granular

The granular glacial deposits were encountered in all the borehole positions but was not recorded in any of the machine excavated trial pits due to their termination depth. This material was largely encountered below the TFD-C and Peat layer. Within 3no. boreholes (BH108, BH110 & BH111) this material was identified below the Cohesive Glacial Till deposits.

It's likely that this granular material represents a glacial meltwater channel within the wider Cohesive Glacial Till deposit. The Granular Glacial Till deposits extended to a proven depth between 6.00m and 8.60m bgl. This material was typically described as:

- Medium dense dark brown slightly sandy GRAVEL with a low cobble content of subrounded sandstone and quartzite. Gravel is subangular to subrounded fine to coarse of sandstone and quartzite.
- Dense dark brown sandy GRAVEL with a low cobble content of subrounded sandstone and quartzite. Gravel is subangular to subrounded fine to coarse of sandstone and quartzite.

4.7. Glacial Till Deposits – Cohesive

This material was encountered within all borehole positions but was not recorded within any of the machine excavated trial pits due to their termination depth. The Cohesive Glacial Till deposits were encountered beneath the Granular Glacial Till deposits except within 3no. boreholes (BH108, BH110 & BH111) where they are recorded beneath the Tidal Flat Deposits and again beneath the Granular Glacial Till deposits. The Cohesive Glacial Till deposits extended to a proven depth between 11.90m and 13.30m bgl. This material was typically described as:

- Firm brownish grey slightly sandy slightly gravelly CLAY with occasional sand/gravel lenses up to 200mm thick. Gravel is subangular to subrounded fine to coarse of sandstone and rare coal.
- Stiff greyish brown/dark brown slightly sandy gravelly CLAY. Gravel is angular to subangular fine to coarse of sandstone and quartzite.
- Very stiff brownish grey slightly sandy gravelly CLAY. Gravel is angular to subangular fine to coarse of sandstone.

There was one entry within BH107 between 4.50m and 5.40m where this material is recorded as “Very soft dark brown slightly gravelly sandy CLAY. This is not viewed as representative of this material.

4.8. Weathered Coal Measures Formation

This material was encountered within all borehole positions but was not recorded within any of the machine excavated trial pits due to their termination depth. This material was encountered beneath the Cohesive Glacial Till deposits and extended to a proven depth of between 14.40m and 18.80m bgl. This material was typically described as:

- Extremely weak grey MUDSTONE, recovered as angular to subangular fine to coarse gravel.
- Extremely weak dark grey MUDSTONE with occasional coal fragments up to 15mm in diameter.
- Stiff grey slightly sandy gravelly CLAY with many mudstone lithorelics up to 100mm in size.

4.9. Coal Measures Formation

The Coal Measures formation was only encountered within 2no. exploratory positions: BH107 & BH109. This was encountered immediately below the weathered coal measures and extended to borehole termination depths of 49.50m bgl. This unit was encountered at 18.

This unit was encountered as interbedded siltstones and mudstones which were typically described as:

- Medium to Very Strong SILTSTONE with rare very strong ironstone nodules.
- Medium to Very Strong SILTSTONE with occasional pyrite crystals and gypsum veins.
- Extremely/Very weak to Medium Strong MUDSTONE.

One entry of coal was logged within BH109 at 42.55m bgl with a thickness of 0.25m bgl.

As part of the wider Phase 1 GI works intact coal was logged within the following boreholes associated with earlier options for the Margam Substation:

- BH101 approximately 110m north of the site, coal logged at 14.50m bgl with a thickness of 0.35m
- BH104 approximately 40m east of the site, coal logged at 15.70m bgl with a thickness of 1.40m.

It should be noted that BH101 and BH104 are located on the northern side of the thrust fault (Section 2.3.3) present north of the site. Therefore, the encountered coal seams appear at significantly shallower depths than those recorded within BH109.

4.10. Summary Ground Model

A series of geological cross sections showing the ground model at the site has been included as Appendix C. This should be used as a reference for material depths and thicknesses within different parts of the site. As the design is still in development, during the detailed design a ground model specific to respective structures is to be developed.

4.11. Visual and olfactory evidence of contamination

As detailed within the 2024 GI (Ref [1]), visual evidence of contamination was noted within one location within the Made Ground, at 0.5m bgl in TP105. This evidence was a slight oily sheen on the groundwater encountered within the Made Ground.

TP105, TP105A and TP105B also had evidence of contamination contained within the Made Ground with colour descriptions including black which is often an indication of more contaminated ground and soil descriptions including slag and ash potentially indicating contaminated ground.

Table 4.2. Visual and olfactory evidence of contamination.

Location	Depth (m bgl)	Comment
TP105	0.20-0.50	Presence of slag within the gravel and oily sheen on water seepage.
TP105A	0.15-0.40	Black gravelly sand with some ash.
TP105A	0.40-2.30	Presence of slag within gravel.
TP105B	0.20-0.80	Presence of slag up to 0.15m in diameter

4.12. Groundwater

Groundwater was observed during the ground investigation within the trial pits and boreholes. Table 4.3 summarises the groundwater strikes with respect to the strata.

Table 4.3. Summary of encountered groundwater.

Exploratory Position	Strata	Strike		After 20 mins – Boreholes only		Comments
		Depth (m bgl)	Level (mAOD)	Depth (m bgl)	Level (mAOD)	
BH105	Topsoil	0.20	2.84	0.20	2.84	
BH105	Granular Glacial Deposits	5.00	-1.96	0.80	2.24	Sub Artesian
BH106	Topsoil	0.00	3.15	0.00	3.15	
BH106	Granular Glacial Deposits	4.70	-1.55	2.10	1.05	
BH107	Granular Glacial Deposits	5.40	-2.45	-0.46	3.41	Artesian

Exploratory Position	Strata	Strike		After 20 mins – Boreholes only		Comments
		Depth (m bgl)	Level (mAOD)	Depth (m bgl)	Level (mAOD)	
BH107	Coal Measures	21.00	-18.05	14.30	-11.35	
BH108	Granular Glacial Deposits	5.80	-2.75	-0.45	3.5	Artesian
BH109	Topsoil	0.10	2.94	0.00	3.04	
BH109	Granular Glacial Deposits	6.00	-2.96	-0.12	3.16	Artesian
BH110	Topsoil	0.00	3.07	0.00	3.07	
BH110	Granular Glacial Deposits	6.00	-2.93	1.90	1.17	
BH111	Topsoil	0.00	3.03	0.00	3.03	
BH111	Granular Glacial Deposits	5.80	-2.77	4.90	-1.87	
TP105A	Made Ground	0.70	2.965	-		Water standing on completion of excavation
TP105B	Made Ground	0.65	2.965	-		
TP108	Tidal Flat Deposits – Cohesive	1.65	1.36	-		
TP109	Tidal Flat Deposits – Peat	1.45	1.59	-		
TP110	Tidal Flat Deposits – Peat	2.60	0.46	-		
TP111	Tidal Flat Deposits – Peat	2.30	0.76	-		
TP112	Tidal Flat Deposits – Cohesive	0.70	2.27	-		
TP113	Tidal Flat Deposits – Peat	1.60	1.48	-		
TP114	Tidal Flat Deposits – Peat	1.20	1.95	-		

In addition to the groundwater level, some seepages were recorded within the topsoil and made ground at the following depths:

- TP105 at 0.50m bgl within the made ground, this was noted to have an oily sheen.
- TP106 at 0.20m bgl within the topsoil.

Due to the shallow groundwater, artesian and sub-artesian ground water conditions encountered during the GI, only 1no. borehole was installed with a gas and groundwater monitoring standpipe for further monitoring after the completion of the GI. This is because in boreholes with artesian conditions needed to be sealed to prevent groundwater flowing to surface. These boreholes were fully sealed with bentonite pellets. It is possible that the groundwater is tidally connected however conclusive evidence of this was not found as it is unlikely to have significant bearing on the design.

At the time of writing this report, 6no. return visits have been undertaken to site to monitor groundwater levels and ground gas on the following dates:

- 20th September 2024
- 30th September 2024
- 6th November 2024
- 20th November 2024
- 10th December 2024
- 17th January 2025

A summary of the groundwater levels monitored to date are presented in Table 4.4.

Table 4.4: Summary of groundwater monitoring.

Exploratory hole	Screen zone (m bgl)	Measured depth to base (m bgl)	Depth of water (m bgl)	Groundwater elevation (mAOD)	Stratum
BH111	1.00-4.50	4.50	0.00	3.03	Tidal Flat Deposits

* Groundwater level could not be measured on the 10/12/24 due to the borehole being inaccessible due to surface water at the site.

4.13. Permeability Tests

During the GI 1no. in-situ rising head permeability test was undertaken in accordance with BS EN ISO 22282-2:2012 (Ref. [23]). The test was undertaken in BH108 at 6.00m bgl within the Granular Glacial Till deposits. The test showed that this material has a permeability of 9.52×10^{-4} m/sec.

4.14. Soakaway Assessments

3no. infiltration tests in accordance with BRE Digest 365 (Ref [24]) were scheduled to be undertaken within TP109, TP110 and TP112 to assess the infiltration performance of the ground and the opportunity for infiltration methods for the Sustainable Drainage Systems (SuDS). Due to the high groundwater encountered in these trial pits the soakaway tests could not be undertaken.

4.15. California Bearing Ratio Results

Two forms of tests were undertaken to assess California Bearing Ratio (CBR) values at the site; in situ Dynamic Cone Penetrometer (DCP) tests and remoulded CBR tests in the laboratory. A summary of the results is provided in Table 4.5.

From the DCP tests undertaken at the site, the in situ CBR values computed for the assumed subgrade formation level between 0.50m and 0.80m bgl were assessed to be in the range of 0.3-302.0%.

Table 4.5: Summary of CBR results for assumed 0.50m – 0.80m subgrade formation level.

Stratum	No. of tests	Method	Thickness nominal CBR (%) range
Tidal Flat Deposits – Cohesive	1	Laboratory	0.22
	8	DCP	0.3 – 16.1
Made Ground	1	DCP	78.6 – 302.0

The CBR values encountered at the site associated with the Tidal Flat Deposits are highly variable and at shallow depths are particularly low. This in combination with the fact that both the cohesive Tidal Flats and Peat are soft materials. Minimum required subgrade CBR for National Grid pavements is 3% therefore some form of improvement would be required as part of the pavement design, this could be the inclusion of geogrids.

4.16. Thermal Resistivity Testing

24no. in situ thermal resistivity tests were undertaken within Trial Pits TP106, TP108 to TP114. 3no. tests were undertaken at 1.20m depth bgl along 3no. sides of the trial pit. Where a test could not be undertaken at 1.2m it was undertaken at 1.00m bgl.

In addition to the in-situ testing, 7no. Laboratory thermal resistivity tests were undertaken on samples collected within the trial pits.

The test results are summarised with respect to each stratum in Table 4.6.

Table 4.6. Summary of Thermal Resistivity Testing.

Stratum	No. of tests	Method	Thermal Resistivity (mK/W) range
Tidal Flat Deposits – Cohesive	2	Laboratory	3.30-3.55
	18	In-Situ	0.61 – 0.87
Flat Deposits – Peat Tidal	2	Laboratory	8.06 – 11.54
	6	In-Situ	0.68 – 1.72
Glacial Till Deposits – Cohesive	2	Laboratory	0.86 – 1.54
Glacial Till Deposits – Granular	1	Laboratory	4.03

5. Ground Conditions and Material Properties

5.1. Introduction

This section of the report provides a summary of the geological strata and a discussion of proposed material indicative parameters and derivation methods. Relevant parameter plots are presented in Appendix B of this report. Proposed outline soil parameters for the site are presented in Table 5.7.

5.2. Topsoil

The topsoil is typically present across the entire site to a maximum depth of up to 0.7m bgl.

It is assumed that the Topsoil will be stripped prior to construction and therefore no strength or compressibility parameters are derived.

5.3. Made Ground

The made ground is present in TP05, TP05A & TP05B up to a depth of 2.30m bgl. Due to the made ground being encountered in 3no. trial pits within close proximity to one another in an area of the site where the only development proposed is a road with no load bearing structures or earthworks, material parameters have therefore not been derived for the made ground.

5.4. Tidal Flat Deposits – Cohesive

The Cohesive Tidal Flat Deposits (TFD-C) were typically encountered as a very soft slightly sandy CLAY with some logs recording occasional pockets of peat between 15mm and 100mm in size.

The plasticity tests conducted on this material shown on Figure B.4 indicate that this material ranges between an intermediate and high plasticity CLAY however is generally a high plasticity CLAY. There is a medium volume change potential in this unit.

The Particle Size Distribution (PSD) results shown in Figure B.8 show that the material is predominantly clay with small fractions of sand and gravel. This is similar to the log descriptions.

9no. SPTs were obtained within this unit, these have been corrected to N60 values using the hammer energy ratio certificates and presented in Figure B.12. The N60 values ranged between 0 and 2. Using a correlation from N60 to undrained shear strength this material has extremely low strength.

A summary of testing and available results undertaken in this geological unit are summarised in Table 5.1.

Table 5.1: Summary of geotechnical testing results for TFD-Cohesive.

Test / Parameter	No. of tests	Value / Range	Assessment
Natural Moisture Content (%)	13	29.9 – 59.6	BS EN ISO 17892-1:2014
Liquid Limit (%)	12	45 - 65	BS EN ISO 17892-12:2018
Plastic Limit (%)	12	21 – 26	
Plasticity Index (PI) (%)	12	24 - 40	
Modified PI (%) ^[1]	12	24 - 38	BRE Digest 240
Organic Content (%)	1	1.6	
Particle Size Distribution [wet sieve]	6	Total percentage:	BS EN ISO 17892-4:2016

		Very coarse: 0 Gravel: 0 - 4 Sand: 1 - 10 Fines (<0.063mm): 86 – 99 1no. Sedimentation Silt: 57 Clay: 29	
Corrected SPT (N60) ^[2]	9	0 - 2	In-situ SPT
CBR Test (%)	3	0.13 – 1.60	BS1377: Part 4
2.5kg Compaction Test	1	Max Dry Density (Mg/m ³): 1.55 Optimum Moisture Content (%): 22	BS1377: Part 4
Permeability (m/s) [Triaxial Permeability Test]	3	1.1-1.8 x 10 ⁻¹⁰	BS EN ISO 17892-11: 2019

- Note:
1. The modified plasticity index has been calculated based upon the percentage passing the 0.425mm sieve to understand the risk of volume change of the material according to BRE Digest 240.
 2. The SPT N values have been corrected to N60 values using the SPT hammer energy ratio

5.5. Tidal Flat Deposits - Peat

The Peat within the Tidal Flat Deposits was typically encountered as a Spongy dark brown fibrous & pseudo fibrous PEAT. The description is representative of peat which has undergone low to moderate decomposition.

The moisture content, shown in Figure B.2, was shown to be typically over 400%.

Two plasticity tests showed that the material to be non-plastic, however one result returned a plastic result which likely coincides with a clay inclusion within the peat.

The 11no. SPT N60 values are plotted within Figure B.11 which all show a value of 0.

A summary of testing and available results undertaken in this geological unit are summarised in Table 5.2.

Table 5.2: Summary of geotechnical testing results for TFD- Peat.

Test / Parameter	No. of tests	Value / Range	Assessment
Natural Moisture Content (%)	13	52.6 - 786	BS EN ISO 17892-1:2014
Liquid Limit (%) ^[1]	3	57 – 740	BS EN ISO 17892-12:2018
Plastic Limit (%) ^[1]	3	NP – 27	
Plasticity Index (PI) (%) ^[1]	3	NP - 30	
Organic Matter	5	5.8 – >25	
Modified PI (%) ^[2]	3	NP - 20	BRE Digest 240
Corrected SPT (N60) ^[3]	11	0	In-situ SPT
Coefficient of volume compressibility, m_v (m²/MN) [One Dimensional Consolidation Test]	2	Overburden: 4.1-5.2	BS EN ISO 17892-5:2017
Coefficient of Consolidation C_v	2	0.5-0.1	BS EN ISO 17892-5:2017

[One Dimensional Consolidation Test]

- Note:
- 1no. Atterberg test returned as plastic which coincides with a logged clayey layer, this is not representative of the wider layer and is therefore not discussed further or included in parameter plots.
 2. The modified plasticity index has been calculated based upon the percentage passing the 0.425mm sieve to understand the risk of volume change of the material according to BRE Digest 240.
 3. The SPT N values have been corrected to N60 values using the SPT hammer energy ratio

5.6. Glacial Till Deposits – Granular

The granular Glacial Till deposits was typically encountered as a medium dense to dense slightly sandy GRAVEL.

The PSD results shown in Figure B.10 confirm this the field description of this material.

20no. SPTs were obtained within this unit, these have been corrected to N60 values using the hammer energy ratio certificates and presented in Figure B.14. Omitting the 2no. refusals the N60 values ranged between 15 and 41. This indicates that the gravel is between medium dense and dense.

A summary of testing and available results undertaken in this geological unit are summarised in Table 5.3.

Table 5.3. Summary of geotechnical testing results for Glacial Deposits – Granular.

Test / Parameter	No. of tests	Value / Range	Assessment
Particle Size Distribution [wet sieve]	6	Total percentage: Very coarse: 0 - 25 Gravel: 62 - 92 Sand: 3 - 35 Fines (<0.063mm): 1 - 3	BS EN ISO 17892-4:2016
Corrected SPT (N60) ^[1]	20	15 – 41 ^[2]	In-situ SPT
Permeability (m/s) [Constant Head Permeameter]	3	1.8×10^{-4} to 4.2×10^{-3}	BS EN ISO 17892-11: 2019

- Note:
1. The SPT N values have been corrected to N60 values using the SPT hammer energy ratio.
 2. 2no. Refusals recorded

5.7. Glacial Till Deposits – Cohesive

The cohesive Glacial Till deposits were typically encountered as a firm to very stiff slightly sandy gravelly CLAY.

The plasticity tests conducted on this material, shown on Figure B.5, show that this material is predominantly a low plasticity CLAY with 2no. results showing an intermediate plasticity CLAY.

The PSD results shown in Figure B.9 show that this material is generally well graded with material consistent with the field descriptions and proportions consistent for a cohesive material.

14no. SPTs were obtained within this unit, these have been corrected to N60 values using the hammer energy ratio certificates and presented in Figure B.13. Omitting the 1no. refusal the N60 values ranged between 23 and 52.

The undrained shear strength obtained from SPT N60 correlations and triaxial tests indicate a high to very high strength clay as shown in Figure B.15. It should be noted that 2no. triaxial tests undertaken which

exhibited compound failure show low to medium undrained shear strengths. These results were significantly less than in situ SPT correlated values and were therefore not considered representative of this material.

A summary of testing and available results undertaken in this geological unit are summarised in Table 5.4.

Table 5.4. Summary of geotechnical testing results for Glacial Deposits – Cohesive.

Test / Parameter	No. of tests	Value / Range	Assessment
Natural Moisture Content (%)	21	10.2 – 25.1	BS1377: Part 2
Liquid Limit (%)	16	21 - 36	BS1377: Part 2
Plastic Limit (%)	16	13 - 17	BS1377: Part 2
Plasticity Index (PI) (%)	16	6 - 19	BS1377: Part 2
Modified PI (%) ^[1]	16	2 – 18	BRE Digest 240
Particle Size Distribution [wet sieve]	7	Total percentage: Very coarse: 0 Gravel: 9 - 39 Sand: 22 - 34 Fines (<0.063mm): 39 – 57 6no. Sedimentation Silt: 26 – 40 Clay: 17 - 22	BS1377: Part 2 (Clause 9.2 & 9.4)
Corrected SPT (N60) ^[2]	14	23 – 52 ^[3]	In-situ SPT
Shear Box Test Peak Angle of Friction, ϕ' (°)	1	26	BS1377: Part 7
Undrained Triaxial Test Single Stage	4	33 - 186	BS EN ISO 17892-8:2018
Coefficient of volume compressibility, mv (m ² /MN) [One Dimensional Consolidation Test]	1	Overburden: 0.41	BS EN ISO 17892-5:2017
Coefficient of Consolidation Cv [One Dimensional Consolidation Test]	1	0.5 – 1.6	BS EN ISO 17892-5:2017
Permeability (m/s) [Triaxial Permeability Test]	3	7.7×10^{-11} to 3.6×10^{-10}	BS EN ISO 17892-11: 2019

Note:

1. The plasticity index has been modified based upon the percentage passing the 0.425mm sieve to understand the risk of volume change of the material according to BRE Digest 240.
2. The SPT N values have been corrected to N60 values using the SPT hammer energy ratios.
3. 1no. Refusal was recorded.

5.8. Weathered Coal Measures Formation

The weathered coal measures was typically encountered as extremely weak MUDSTONE recovered as angular to subangular gravel.

All of the SPTs within the weathered coal measures were refusals. The recovery of material as a gravel is likely a product of the drilling method. In-situ the weathered formation is likely an extremely weak mudstone.

A summary of testing and available results undertaken in this geological unit are summarised in Table 5.5.

Table 5.5. Summary of geotechnical testing results for Weathered Coal Measures Formation.

Test / Parameter	No. of tests	Value / Range	Assessment
Corrected SPT (N60) ^[1]	12	56 ^[2]	In-situ SPT

Note:

1. The SPT N values have been corrected to N60 values using the SPT hammer energy ratio
2. All SPT values were refusals

5.9. Coal Measures Formation

The coal measures formation was typically encountered as a medium to very Strong SILTSTONE with some layers of weak to medium strong MUDSTONE.

The Unconfined Compressive Strength (UCS) and point load testing undertaken on this formation is shown to be highly variable see Figure B.19, values are largely shown to be less than 50MPa but there is no clear correlation with depth and no relationship between the UCS values within the siltstone layers as opposed to the mudstone layers.

A summary of testing and available results undertaken in this geological unit are summarised in Table 5.6.

Table 5.6. Summary of geotechnical testing results for Coal Measures Formation.

Test / Parameter	No. of tests	Value / Range	Assessment
Axial Point Load Tests, converted UCS MPa ^[1]	14	1.3 – 154.0	ISRM Methods
Uniaxial Compressive Strength (UCS) MPa	6	4.3 – 81.4	ASTM D7012-14 Method C
Water Content (%)	20	0.4 – 3.6	In above tests

Note:

1. UCS values have been converted using a factor based on tested rock type. Values reported are axial UCS only.

5.10. Assessment of Geotechnical Design Parameters

5.10.1. General

Geotechnical design parameters for each of the geological units has been determined based on:

- Laboratory test results;
- Published literature;
- Engineering judgement.

Unless stated, these values will be selected in accordance with BS8004:2015 (Ref [25]) and Eurocode 7 (Ref [2], [3]).

5.10.2. Unit weight

The unit weight of the geological units has been determined based upon:

- Material descriptions and in-situ tests
- BS 8004 (Ref [25]) which presents typical weight density ranges for materials.

The indicative unit weights for each geological unit are presented in Table 5.7.

5.10.3. Effective Friction Angle

The effective friction angle has been derived based on:

- Material descriptions and PSD results;
- Empirical correlation using SPT N60 values and soil plasticity index parameters.
- Shear Box testing
- Values from literature

The angle of friction for cohesive soils has been determined from the correlation between plasticity index and the critical state angle of shearing resistance as presented in BS 8002:2015 (Ref [26]):

$$\varphi'_{cv} = 42^\circ - 12.5 \times \log_{10} PI$$

The angle of friction for granular soils is based on correlations presented in BS8002:2015 (Ref [26]):

$$\varphi'_{pk,k} = \varphi'_{cv,k} + \varphi'_{dil}$$

Where:

$\varphi'_{cv,k}$ Critical state angle of friction of the soil and is given by:

$$\varphi'_{cv,k} = 30^\circ + \varphi'_{ang} + \varphi'_{PSD}$$

φ'_{ang} is the contribution due to the angularity of the soil particles;

φ'_{PSD} is the contribution due to the soil's particle size distribution;

φ'_{dil} is the contribution to the critical state angle due to soil dilatancy.

The recommended effective angle of friction for each geological unit are presented in Table 5.7.

5.10.4. Undrained Shear Strength

The undrained shear strength of cohesive soils has been assessed using the following:

- In situ hand shear vane tests;
- Laboratory undrained triaxial tests;
- Empirical correlations using SPT N60 values
- Values from literature

The correlation by Stroud presented in CIRIA 143 (Ref [27]) has been used to derive the undrained shear strength (C_u) of cohesive soils from SPT N60 values:

$$C_u = f_1 \times N$$

f_1 is based on the design plasticity index for the unit. For the cohesive Glacial deposits a f_1 value of 6 has been assumed. For the cohesive Tidal Flat deposits a f_1 value of 4.5 has been assumed.

The recommended undrained shear strengths for each geological unit are presented in Table 5.7.

5.10.5. Undrained Young's Modulus

The undrained Young's Modulus (E_u) of the units has been assessed using the following:

- Empirical correlation using SPT N60 values

The correlation presented in CIRIA 143 (Ref [27]) has been used to derive the undrained Young's Modulus of cohesive soils from SPT N60 values:

$$E_u = (1.0 - 1.2) \times N60$$

The recommended stiffness parameters for each unit are presented in Table 5.7.

5.10.6. Drained Young's Modulus

The drained Young's Modulus of the units has been assessed using the following:

- Conversion from the undrained modulus using Worth (1972) relationship;
- Empirical correlations using SPT N60 values

Worth (1972) stated that the drained modulus of cohesive soils is related to the undrained modulus by the following:

$$E' = \frac{2(1 + \nu)}{3} \times E_u$$

Where:

ν Poisson's ratio

The correlation by Stroud presented in CIRIA 143 (Ref [27]) has been used to derive the drained Young's modulus from corrected SPT N60 values:

$$E' = 0.90 \times N60 \text{ (in MPa)}$$

Poisson's ratio is typically between 0.20 and 0.45, with a lower Poisson ratio applied to stiff/dense soils increasing to 0.45 for soft/loose materials (Ref [28]).

5.10.7. Compressibility

Coefficient of volume compressibility has been assessed using the following:

- Laboratory oedometer test;
- Empirical correlations using SPT N60 values
- Values from literature

The correlation presented in CIRIA 143 (Ref [27]) has been used to derive the coefficient of volume compressibility from corrected SPT N60 values:

$$m_v (\text{m}^2/\text{MN}) = \frac{1}{f_2} \times N$$

f_2 coefficient is based on the design plasticity index for the unit from CIRIA 143 (Ref [27])

5.10.8. Uniaxial Compressive Strength

The Uniaxial Compressive Strength (UCS) has been calculated based on:

- UCS laboratory testing
- Point Load Index Laboratory testing

The point load index values have been converted to UCS using the following equation:

$$\text{UCS (MPa)} = I_s(50) \times k$$

K is the conversion factor based on rock type from Rusnak and Mark (2000) where:

- $k = 20.0$ (Siltstone)
- $k = 12.0$ (Mudstone)

5.11. Indicative Design Parameters

The indicative design values have been determined for each geotechnical design parameter in accordance with Eurocode 7 (BS EN 1997-1:2004+A1:2013): Geotechnical Design (Ref [2]), from values measured directly in situ, by laboratory testing or by correlation of values derived empirically and indirectly by in situ or laboratory testing. Where it was not possible to derive values directly or indirectly, published values were consulted (with engineering judgement and experience) to establish an appropriate value for a particular geotechnical parameter.

Presented in Table 5.7 are the outline values proposed for the geological units expected at the site. Note that topsoil has not been included as it is anticipated to be removed during construction works. Design parameters for the made ground have not been developed as it was encountered in a localised area at the northern part of the site where no major load bearing structures are proposed. Currently a new access road is proposed in the area where made ground is present therefore it's likely that the construction thickness of the road will increase or there will be incorporation of geogrid to account for the made ground.

Table 5.7: Material indicative parameters.

Material Parameter	Tidal Flat Deposits – Cohesive	Tidal Flat Deposits - Peat	Glacial Deposits – Granular	Glacial Deposits – Cohesive	Weathered Coal Measures	Coal Measures	Derivation Notes
Unit weight, γ (kN/m ³)	18	12	20	22	24	24	Value for TFD-C based on indicative weight density from BS8004:2015 (Ref. [25]). Value for Peat from Table 1 from Ref ([29]) Value for Glacial Deposits – Granular developed from SPT N Values using CIRIA 143 (Ref. [27]) and values for indicative weight density from BS8004:2015 (Ref. [25]) Value for Glacial Deposits – Cohesive values for indicative weight density from BS8004:2015 (Ref. [25])
Effective angle of friction (°)	22	N/A	34	27	20-27 (Mudstone)	27-34 (Siltstone) 20-27 (Mudstone)	TFD-C value determined from equation in BS8004:2015 (Ref. [25]) for fine grained soils using the 75th Percentile for PI: $\phi'_{cv} = 42^\circ - 12.5 \times \log_{10} PI$ Glacial Deposits-C determined from above correlation and shear box result. Glacial Deposits-G value based on the 25th Percentile N60 value and Figure 36 presented in CIRIA 143 (Ref. [27]).
Effective cohesion, c' (kPa)	0	0	0	0	0	0	
Undrained shear strength, C_u (kPa)	10	5	N/A	140	N/A	N/A	TFD-C determined from estimate of limited in-situ hand shear vanes. TFD- Peat determined from values presented in Ref ([29]).

Material Parameter	Tidal Flat Deposits – Cohesive	Tidal Flat Deposits - Peat	Glacial Deposits – Granular	Glacial Deposits – Cohesive	Weathered Coal Measures	Coal Measures	Derivation Notes
							Glacial Deposits – C determined from the 25 th Percentile SPT and correlation as per Stroud in CIRIA 143 with an f_1 value of 4.5 and 2no. undrained triaxial tests. 2no. other triaxial tests recorded uncharacteristically low C_u values which were a function of a compound failure mode therefore these results were not considered.
Undrained Young's Modulus, E_u (MPa)	1	0.1-0.5	N/A	31	N/A	N/A	TFD-C based on equation 2 for high plasticity clays from Ref ([30]) $E_u = 100 \times C_u$ Peat range calculated based on inverse of M_v value Glacial Deposits-C range based on 25th Percentile of SPT N60 value. Correlation presented in CIRIA C143 (Ref. [27]): $E_u = (1.0 - 1.2) \times N60$
Drained Young's Modulus, E (MPa)	1	0.1-0.5	23	28	N/A	N/A	TFD-C and Peat value based on correlation presented in Worth (1972) between drained and undrained Young's modulus where $v=0.5$: $E' = \frac{2(1 + v)}{3} \times E_u$ Glacial Deposits-C and Glacial Deposits-G based on Percentile of SPT N60 value. Correlation presented in CIRIA C143 (Ref [27]) For cohesive materials: $E' = 0.9 \times N60$ For granular materials: $E' = 1.0 \times N60$

Material Parameter	Tidal Flat Deposits – Cohesive	Tidal Flat Deposits - Peat	Glacial Deposits – Granular	Glacial Deposits – Cohesive	Weathered Coal Measures	Coal Measures	Derivation Notes
Coefficient of volume compressibility, m_v (m^2/MN)	>1.50	6.5-7.6	N/A	0.41	N/A	N/A	Tidal Flat Deposits- C determined from Table 2.11 from Tomlinson (Ref. [31]) upper bound determined from SPT Tidal Flat Deposits – Peat determined from Oedometer testing for in-situ loads. Glacial Deposits-C range based Oedometer test results for in-situ loads.
Permeability (m/s)	1.8×10^{-10}		4.2×10^{-3}	3.6×10^{-10}			Tidal Flat Deposits – Cohesive, Glacial Deposits Granular & Cohesive values determined from upper bound laboratory permeability testing results.
Unconfined Compressive Strength (MPa)	N/A	N/A	N/A	N/A	0.6-1.0	6.5	Weathered Coal Measures value from Table 2 in BS EN 14689-2018 for extremely weak rock (Ref. [32]). Coal Measures Value determined from 25th percentile of the UCS results.

5.12. Buried Concrete Design

17no. BRE Suite D tests were scheduled to assess potentially aggressive ground conditions at the site to assess the potentially aggressive ground conditions to inform the concrete design. The assessment was done assuming brownfield site conditions with pyrite present and mobile groundwater.

The indicative values and design classes have been assigned in accordance with BRE Special Digest 1 (SD1) (Ref [33]) and the proposed Aggressive Chemical Environment for Concrete (ACEC) classification is presented in Table 5.8 below.

It should be noted that gypsum was recorded within BH107 & BH109 within the rock mass at depth, inclusion of gypsum can result in elevated sulphate levels which could result in a requirement for a higher class of concrete. Peat can also have acidic pH which could have a bearing on concrete classification.

Table 5.8: BRE Suite D test results and classification.

Test Parameter	Units	Made Ground	Tidal Flat Deposits – Cohesive & Peat	Glacial Deposits – Cohesive	Glacial Deposits – Granular
No. of tests	-	1	8	5	3
Sample Depth Range (m bgl)	m bgl	1.50	0.50-3.20	4.80-11.80	6.00-7.00
pH		10	5.4-7.8	6.8-12.2	7.0-7.9
Sulphate (2:1 Water Soluble) as SO ₄	mg/l	260	47-1300	12-1400	17-77
Total Sulphur (%)		0.3	0.01-1.40	0.02-0.11	<0.01-0.02
Total Potential Sulphate (%)		0.9	0.03-4.20	0.06-0.33	0.03-0.06
Characteristic 2:1 SO ₄ Sulphate	mg/l	260 Highest 2:1 SO ₄	1200 Mean of the 2no. highest.	940 Mean of the 2no. highest	77 Highest 2:1 SO ₄
Characteristic Total Potential Sulphate (TPS) (%)		0.9 Highest TPS	3.59 Mean of the 2no. highest TPS	0.285 Mean of the 2no. highest TPS	0.06 Highest TPS
Characteristic pH		10 Lowest pH	5.7 Mean of the 2no. lowest pH	7.1 Mean of the 2no. lowest pH	7.0 Lowest pH
Design Sulphate Class	-	DS-3	DS-4*	DS-2	DS-1
ACEC Class	-	AC-3	AC-5	AC-2	AC-1

6. Contamination Assessment

6.1. Introduction

The assessment undertaken herein has been carried out generally in accordance with the current best-practice guidance for the assessment of land contamination as contained in the LCRM (Ref [34]).

Soil samples were obtained from the site during the ground investigation works and subjected to laboratory analytical testing in order to inform the assessment of the risks posed to human health (construction workers, future site users), and controlled waters from the presence of potential contaminant sources.

Further evaluation of the likely presence of pollutant linkages relevant to the site in its current state and after development has been undertaken to inform if there are further development implications for the scheme.

All chemical analyses were undertaken by the UKAS accredited Derwentside Environmental Testing Services Limited (DETS); the results of which are discussed in the following sections.

Laboratory analytical results are appended within the Factual Report provided in Appendix A.

6.2. Human Health Risk Assessment - Soils

6.2.1. Risk Assessment Criteria

Total soil chemical results were directly compared to appropriate Human Health Assessment Criteria (HHAC) LQM/CIEH S4UL (Ref [35]) and DEFRA C4SL (Ref [36]) and are summarised in the below sections.

Soils have been screened against a commercial land use based on the intended site development as an industrial facility (proposed new GIS substation) HHAC have been formulated with suitable consideration to associated pollution linkages, comprising inhalation, ingestion and dermal contact with soil / dust and inhalation of vapours associated with volatile compounds. Further details regarding the specific HHAC used is presented in Appendix C.

The assessment is based on the following assumptions:

- Suitable 4 Use Levels (S4UL) thresholds are used to the nearest Soil Organic Matter (SOM) percentage deemed appropriate (1%, 2.5% or 6%).
- The proposed site end use is of a low-risk rating (commercial/industrial). For analysis purposes, commercial is deemed the most appropriate end use.
- Geology beneath the site has been classified as a Secondary Undifferentiated Aquifer for superficial deposits and a Secondary A Aquifer for bedrock. Some protection of the bedrock aquifer (Secondary A Aquifer) would be afforded by the cohesive nature of the shallow Tidal Flat Deposits and the deeper Glacial Till Deposits. The site is not located within a Source Protection Zone.
- It is deemed that statistical analysis is not appropriate given the level of sample data and results being relatively low risk.
- Site history has indicated a **very low** risk of contamination.
- Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures, therefore, the primary residual risks that require assessment are Site End Users.

6.2.2. Deviating Samples

Deviating samples are associated with results contained within the Geotechnics Factual Report (Ref. [1]). Deviations relate to an exceedance of holding times for pH, conductivity, total sulphur, Chromium, Hexavalent (4 days), Kone (4 days), pH/Cond (1 days), Ammoniacal Nitrogen as NH₄ (10 days), Ammoniacal Nitrogen as NH₃ (10 days), Ni

trite as NO₂ (5 days), PAH MS (4 days), SVOC (7 days) and one inappropriate container for tests (TP101 0.50m VOC) Detailed below in Table 6.1. Full detail is provided within the laboratory testing certificates contained within the Geotechnics Factual Ground Investigation Report, included as Appendix A.

Table 6.1 Deviating Sample List.

Location ID and Depth (m bgl)	Tests Deviating	Reason
BH101 (0.50), TP105 (0.15, 0.40), TP105A (0.15, 1.40), TP106 (0.50) BH105 (0.25), TP107 (0.25), TP108 (0.20), TP109 (0.20), TP112 (0.25), BH111 (0.25, 0.50)	pH + Conductivity, VOC	Holding Time
BH102 3.00	Total sulphur + pH	Holding Time
TP101 0.50, TP115 0.50, BH106 (0.25), BH111 (0.25) TP105A 1.4, TP105 0.4	VOC	Inappropriate Container
TP105 0.15, 0.40 TP105A 0.15, 1.40 BH111 (0.25) Leachate	Chromium, Hexavalent Kone pH/Cond Ammoniacal Nitrogen as NH ₄ Ammoniacal Nitrogen as NH ₃ , Nitrite as NO ₂ , PAH MS, SVOC	Holding Time
BH103 (1.00), BH104 (1.00), TP101 (0.50), TP104 (2.00), TP105A (1.40-1.50)	Anions 2:1, Total Sulphur, Total Sulphate ICP, pH + Conductivity	Holding Time
BH103 (2.20-3.20), BH103 (3.20-3.80), BH104 (2.80), TP103 (1.80-2.00) TP108 (2.50), TP109 (1.40-2.00), TP106 (2.00-2.20)	Organic Matter (Manual)	Holding Time

Deviating samples are noted where the laboratory cannot confirm the integrity of the sample and as such laboratory results may be associated with differing concentrations to existing ground conditions.

6.2.3. Summary of Results

All 42no. samples subjected to laboratory testing returned results below the adopted screening criteria for commercial LQM/CIEH S4UL thresholds.

Screening of 42no. samples for asbestos content did not return any positive results.

As a result, it is considered that the soils collected from the near surface do not have the potential to present a significant risk to human health based on the proposed commercial end use.

Localised Total Petroleum Hydrocarbons were recorded within location TP115 0.2m bgl. Whilst the result falls below the adopted screening value total TPH was recorded with a concentration of 1,400mg/kg for chain length C21-35. Further consideration should be given to impact on disposal classification as is discussed further in Section 6.5.5

The assessment is appended to this report in Appendix C.

6.3. Controlled Waters Risk Assessment

Laboratory analytical results are appended within the Factual Report provided in Appendix A and associated screening is presented within Appendix C.

The results have been compared against UK Drinking Water Standards, WHO Guidelines for Drinking Water Quality (4th Edition 2011) and Environmental Quality Standards to provide a conservative assessment of the potential risk to sensitive receptors.

6.3.1. Groundwater Samples

A single groundwater sample was collected from location BH112 with all results below the adopted screening criteria.

6.3.2. Leachate Samples

Leachate testing was completed on 6no. samples from across the site to provide an assessment of risk associated with near surface concentrations. Leachate testing by the test method is considered to represent a worse case assessment of concentrations, such that screening of results to water quality standards can be deemed precautionary. However, screening of leachate samples returned results at the limit of detection or below the adopted screening criteria.

6.3.3. Discussion

Based on the above testing, with both groundwater and leachate samples returning results below the adopted screening criteria or limit of detection it is considered that near surface concentrations within the development area do not represent a significant risk to Controlled Waters.

6.4. Ground Gas Risk Assessment

6.4.1. General

Ground Gas Risk Assessment should be completed in general accordance with current British Standards and technical guidance, BS8576:2011 (Ref [37]), BS8485:2015+A1:2019 (Ref [38]) and CIRIA 665 [39].

The empirical semi-quantitative approach is based on the calculation of Gas Screening Values (GSV), as defined by BS8485 (Ref [38]). GSV are calculated by via assessment of gas concentration and gas flow rate, whilst considering of influencing factors.

CIRIA 665 (Ref [39]) states that typically six monitoring visits should be undertaken over a period of three months, with some visits to be undertaken in atmospheric conditions below 1000 mBar.

6.4.2. Ground Gas Boreholes Installations

As presented in Section 4.12, 2no. boreholes (BH111 and BH112) were installed with gas and groundwater instrumentation for monitoring purposes. Due to the presence of shallow groundwater, response zones were flooded such that it was not possible to complete ground gas screening during the monitoring period.

In order to further assess risks, consideration should be given to the Conceptual Site Model and potential for sources of ground gas within 250m of the site.

6.4.3. Ground Gas Sources

The Conceptual Site Model did not identify any sources of ground gas on site. However, two off site sources of ground gas within 250m have been identified relating to Made Ground associated with the surrounding current and historic use as a Steel Works (190m west) and infilled ponds (180m north) alongside the presence of drainage ditches around the site.

Following the site investigation, a potential source has been identified associated with the fine grained deposits, which were noted to be variable with general thicknesses of between 3.2m-7.0m of cohesive and organic soil including peat. The presence of these materials is a likely low generation source but has the potential to contain high concentrations of methane and carbon dioxide.

6.4.4. Risk Assessment

The precise ground gas regime at the site is currently unknown due to the artesian groundwater conditions at the site. However, due to the cohesive nature of the overlying superficial strata which inhibits permeability to such a degree that artesian groundwater is contained, the unit may be considered sufficient to limit ground gas movement in natural conditions, ie where a pathway is not introduced.

Given the low likelihood of migration from off-site sources due to the cohesive nature of the shallow superficial deposits and high groundwater table limiting lateral migration, it is considered that the only significant potentially active SPR linkage for ground gas at the site is the peat and organic soils below the site. Given these are a low generation potential and, due to the presence of ground water, consistently flooded it is considered highly unlikely that significant flows of ground gas would be generated within the organic stratum. This is supported by CL:AIRE Research Bulletin RB17 (Ref [40]); A pragmatic approach to ground gas risk assessment, which suggests the following;

Alluvial soils and buried peat can quite often give high concentrations of methane and carbon dioxide in monitoring wells, often methane concentrations can reach up to 90%. This is because the gas has been generated historically and is trapped in the pores due to limited transport (at low diffusion rates). The methane accumulates at increasing depth in peat columns, but this does not indicate high rates of production (Clymo and Bryant, 2008; Fritz et al., 2011).

There is no, or very little, current gas generation and the carbon dioxide has dissolved out of the gas trapped in the soil pores which causes a higher percentage of methane to be recorded. Experience on many dockland and similar sites has shown that sites on Alluvial soils^[1] do not generate sufficient hazardous gas flows to exceed Characteristic Situation 2 as defined in BS 8485: 2007 (this has been demonstrated by monitoring under floor venting systems – Wilson and Card, 1999). Therefore, if gas monitoring is not undertaken it is acceptable to simply install Characteristic Situation 2 protection on sites where Alluvial soils are present.

^[1]While Alluvial soils are not present at the site the Peat deposits within the shallow cohesive deposits are likely to behave in the same way due to the nature of the deposits.

Due to the shallow groundwater and artesian aspects at the site restricting ground gas monitoring it is considered that an assumption of a Characteristic Situation 2 protective measure may be undertaken to eliminate residual risk from the ground gas sources on the site.

In line with technical guidance set out in RB17 and in conjunction with the confined nature of underlying groundwater it is considered that Characteristic Situation 2 (CS-2) may be adopted for any structures constructed across the site.

Subsequent site specific risk assessment may allow revision in the gas classification, however this would be represent a separate package of work.

6.4.5. Typical Gas Protection Measures

For a site classified as CS-2 the following options are suggested as methods of ground gas protection; a) reinforced concrete cast in situ floor slab (suspended, non suspended or raft) with minimum 1200g DPM b) block and beam or precast concrete slab and minimum 2000g DPM/or reinforced gas membrane c) possibly under-floor venting or pressurisation in combination with a) and b) depending on use. All joints and penetrations sealed. The classification should be completed in line with BS8485 Table 5 and 6 (Ref [38]).

Due to potential depleted oxygen levels, access to trenches should be limited, or with the use of specific gas alarms. Control measures should be determined by the Principal Contractor.

It is advisable that all gas protection measures are agreed with the regulator prior to adoption in construction.

6.4.6. Ground Gas Requirements – Radon

As set out in the Phase 1 Desk Top Study, the site is in a lower probability radon area (less than 1% of properties are estimated to be at or above the Action Level). As a result no radon protective measures are necessary in the construction of the proposed scheme.

6.5. Construction Implications

6.5.1. Remedial Requirements

The human health risk assessment has confirmed that screened soils do not have the potential to present a significant risk to future site users based on the intended development proposal. Testing of leachate and groundwater samples has not returned any elevated concentrations. In view of this, it is considered that the development area does not have the potential to present a significant risk to Controlled Waters. As a result it is considered that remediation of the site soils/groundwater is unlikely to be required for the proposed site use.

6.5.2. Soils re-use

The human health risk assessment presented above has confirmed that soils comply with the adopted screening criteria, however localised Total Petroleum Hydrocarbon concentration has been identified associated within TP115 0.2m bgl. Whilst values fall below the adopted screening criteria the concentration are associated with an Elevated Classification for disposal off site. The extent of concentrations are unknown such that the immediate area should be confirmed to allow confirmation of disposal costs and avoid mixing of soils during excavation works. This may be completed as part of site enabling works, with waste management documentation produced to set out necessary materials handling, excavation, segregation and disposal process.

6.5.3. CL:AIRE Code of Practice – Materials Management

Once extents of elevated concentrations are known, the re-use of site won material within the site development or at an off-site location should be possible where compliant with methodology set out within the CL:AIRE Definition of Waste: Development Industry Code of Practice (Ref [41]). As such, where material reuse is proposed under the framework, it will be necessary for the Contractor to produce a Materials Management Plan, clearly and accurately detailing the proposed materials management scheme for the site. This should be completed before any materials have been excavated.

6.5.4. Risk to Construction Workers

No formal screening criteria are available for assessing risks to construction workers from short-term exposure to contaminants in soil. As set out above, elevated concentrations above the screening criteria were not identified within the near surface. As a result, it is considered unlikely that near surface soils within the development footprint will present an unacceptable risk to construction workers.

6.5.5. Waste Assessment

In accordance with the Landfill Regulations (2005) and Waste Framework Directive (WFD) (2008/98/EC), it is a statutory requirement that a waste is characterised and meets specific Waste Acceptance Criteria (WAC) prior to disposal at a landfill site. The waste producer has a Duty of Care to ensure that the waste is characterised, and the landfill operator must also be satisfied that a basic characterisation, is properly completed before the waste is accepted.

The basic characterisation requires solids testing for potential contaminants, derived from the knowledge of the site followed by a hazardous/hazardous assessment of the potential contaminants following the Environment Agency (EA) / SEPA regulatory guidance, 'Hazardous Waste: Interpretation of the definition and classification of hazardous waste, Technical Guidance WM3' (2015).

The Waste Acceptance Criteria (WAC) became mandatory in 2005 following the introduction of the Landfill Regulations. Landfills are classified according to whether they can accept hazardous, non-hazardous or inert wastes. Wastes can only be accepted at a landfill if they meet the waste acceptance criteria (WAC) for that class of landfill. The WAC testing includes solids and leachate testing to assess which class of landfill the waste may be accepted at.

Currently there are only acceptance criteria for inert, stable-non-reactive hazardous and hazardous landfills (SNRH). This means that WAC testing is only required for wastes destined for Inert, SNRH and Hazardous landfills.

It should be noted that the results of the assessments presented herein can only be seen as indicative as the final acceptance of any waste is at the sole discretion of the individual landfill operator. As such it is recommended that the results of assessment presented here are passed to the landfill operator to confirm the waste classification.

6.5.6. Waste Acceptance Criteria

WAC classification has been undertaken on 10no. samples obtained during the ground investigation.

Table 6.2 presents the WAC test results and comparison with the relevant WAC thresholds. Where classification exceedance varies by determinant this has been noted within the exceedance column alongside the overall likely classification.

Table 6.2: WAC Results.

Sample ID	Sample Depth (m bgl)	Likely Classification	Exceedances
BH103	0.5	<i>Inert*</i>	<i>n/a</i>
TP101	0.25	<i>Stable Non-Reactive Hazardous</i>	<i>TOC</i>
TP118	0.5	<i>Hazardous</i>	<i>TOC, LOI</i>
TP115	0.5	<i>Inert*</i>	<i>n/a</i>
TP105B	0.5	<i>Inert*</i>	<i>n/a</i>
BH112	0.4	<i>Inert*</i>	<i>n/a</i>
TP103	0.15	<i>Inert*</i>	<i>n/a</i>
TP104	0.25	<i>Inert*</i>	<i>n/a</i>
TP105	0.2	<i>Inert*</i>	<i>n/a</i>
TP105A	0.7	<i>Stable Non-Reactive Hazardous</i>	<i>TOC</i>

*Compliant with Inert criteria for determinants tested.

With reference to Section 6.2.3, asbestos content was not identified in any sample across the site.

HAZWASTEONLINE

HazWasteOnline screening was completed on a selection of soil samples generally aligning with the locations tested for WAC. The output sheets demonstrate that of the 11no. samples screened the material is predominantly classified as Non-Hazardous, with a single result associated with a Hazardous classification.

Table 6.3: Preliminary HazWasteOnline Assessment.

Sample Location	Sample Depth (m bgl)	Classification	Hazard Properties
BH103	0.5	Non Hazardous	-
TP101	0.25	Non Hazardous	-
BH112	0.5	Non Hazardous	-
TP103	0.5	Non Hazardous	-
TP104	0.5	Non Hazardous	-
TP105	0.15	Non Hazardous	-
TP105A	0.15	Non Hazardous	-
TP105A	1.4	Non Hazardous	-
TP111	0.25	Non Hazardous	-
TP118	0.25	Non Hazardous	-
TP115	0.2	Hazardous	HP3, HP7, HP11

Summary-

WAC testing has returned results above the trigger value for Stable Non Reactive for two samples associated with Total Organic Content and Hazardous for Loss of Ignition. Screening of soils in line with WM3 guidance has returned a Non Hazardous classification for soils tested, alongside a Hazardous result associated with the presence of hydrocarbons within TP115 at a depth of 0.2m. Review of the chemical testing associates the classification with a value of 2,600 mg/kg. This result is located near to existing infrastructure, such that redevelopment works may lead to excavation of this material. Further assessment should be completed as part of site progression including delineation and determination of procedures for material handling.

Discussion should be held with the receiver to allow confirmation of disposal classification utilising all chemical testing results contained in this report and assessment against the licence held by the receiver.

In accordance with regulations, any uncontaminated natural ground (excluding topsoil where present) should be suitable for disposal to an inert or non-hazardous landfill.

In line with best practice, sampling of material due for disposal should be completed in accordance with Appendix D of WM3 (Technical Guidance, EA 2018) (Ref [14]). This must be completed to allow suitable, comprehensive assessment and waste classification. Sampling should be proportionate to the volume of materials and with regards to heterogeneity.

6.5.7. Unforeseen Contamination

There are inherent uncertainties associated with environmental sampling of heterogeneous subsurface materials and the potential for encountering unidentified / unforeseen contamination. Therefore, it is recommended that a watching brief is maintained for potential contamination during groundwork at the site. No allowance for ground conditions between the exploratory hole locations can be made.

Any potentially contaminated materials, which differ from those identified during the ground investigation should be segregated and subjected to sampling and appropriate analysis. Assessment of the material should be undertaken to determine, the suitability of the material for re-use within the scheme, re-use offsite, or for off-site disposal in accordance with UK best practice, and regulatory requirements.

7. Refined Environmental Conceptual Site Model

Based upon the findings of the ground investigation, the Conceptual Model has been refined as presented in Table 7.1.

Table 7.1. Revised Conceptual Site Model

Source	Potential Receptor	Likelihood of Occurrence	Discussion of Pollution Linkage
Organic soils generating ground gas.	Future Site Users	Low	Gas protection measures in line with CS-2 may be adopted.*

*Subsequent site specific risk assessment may allow revision in the gas classification, however this would be represent a separate package of work.

8. Geotechnical Risk Register

The geotechnical risk register has been developed based on information and observations on site including the results of the ground investigations completed. The risk register focuses and contains the key geotechnical elements for consideration during the next project phase.

The scoring system adopted for the risk register utilised the following:

- The probability of occurrence ('P') (Table 8.1)
- The impact of occurrence ('I') (Table 8.2)
- The overall risk rating ('R') calculated ('P' multiplied by 'I') (Table 8.3)

The complete geotechnical risk register is presented in Table 8.4.

In addition to the risk the appropriate risk owner at this stage is presented as Client (CL), Designer (D) or Contractor (CO).

Table 8.1: Probability of occurrence (P)

Probability (P)	1	2	3	4	5
Description	Negligible	Unlikely	Probable	Likely	Very Likely

Table 8.2: Impact of occurrence (I)

Impact (I)		Programme	Health and Safety	Environment	Cost
Very High	5	>10 weeks' impact on completion date	Multiple fatalities	Major environmental incident with irreversible effects and threat to public health or protected natural resource.	>£1M
High	4	> 1 week on impact completion date	Fatality	Environmental incident leading to prosecution or protester action	£100K-£1M
Medium	3	> 4 weeks on activity: < 1 week on completion date	Major injury	Environmental incident requiring management input	£10K-£100K
Low	2	1 to 4 weeks on activity: none on completion date	Minor injury	Minor environmental incident	£1K-£10K
Very Low	1	1 week to activity: none on completion date	Negligible	Negligible	<£1K

Table 8.3: Overall risk rating (R)

Risk Rating (R)	1 to 4	5 to 8	9 to 12	13 to 25
Risk Response	Monitor	Regular Attention	Early Attention	Unacceptable

Table 8.4: Geotechnical Risk Register.

Item	Hazard	Risk	P	I	R	Consequence	Mitigation	P	I	R
1	Information reviewed from GI not being representative of in situ conditions.	GI undertaken at discreet locations. Ground conditions may vary between these locations. Therefore, Geotechnical Parameters and ground model outlined within this report might not fully be representative of ground conditions at the site	3	4	12	Inaccurate detailed design leading to potential excessive settlements, failure of foundations, structures and significant re-design, remedial costs.	Parameter selection has been undertaken using engineering judgement with data collected and guidance in EC7. Design will include the use of EC7 partial factors to further mitigate risk. (D)	2	4	8
2	Unforeseen Ground Conditions	Ground Investigation was scoped as part of the existing Margam Substation footprint detailed in Section 1.3. If changes are made to the proposed substation layout, then there is a risk of this GI being insufficient for detailed design.	3	4	12	Inability to undertake detailed design due to lack of information.	Undertake further GI if changes in scope occur prior to construction to enable detailed design. (CL)	2	4	8
3	Slag identified in Made Ground	Potential for swelling of slag within Made Ground	3	4	12	Heave and damage to foundations and access tracks.	Slag identified in localised area where an access track is proposed. If during construction made ground is found to be more extensive, it is recommended that additional testing to establish potential swelling from slag is to be undertaken. (CO)	2	4	8
4	Potential Unrecorded Shallow Mine Working	Proposed substation within influencing distance of an unrecorded worked coal seam.	3	4	12	Excessive settlements of structures and ground collapse leading to damage to structures rendering them unsafe.	A Coal Mining Risk Assessment was completed, with 2no. rotary boreholes scoped as part of GI works to investigate the stratigraphy beneath substation. No observable evidence of any worked seams was identified.	2	4	8
5	Highly Compressible Cohesive Material and Peat present at shallow depths and considerable thicknesses.	Excessive short-term primary and long-term secondary settlements are likely with any placed fill at the site. This will lead to settlement of the substation	3	4	12	Damage to drainage structures, shallow foundations rendering them unsuitable for	Optioneering for ground improvement was undertaken to advise on appropriate methods. (CI)	2	4	8

Item	Hazard	Risk	P	I	R	Consequence	Mitigation	P	I	R
		platform and any supported shallow foundations.				function/unsafe. Inability to excavate materials due to considerable thickness.	Drainage design may need to be flexible to allow for settlement, including long-term maintenance (D). Ground improvement and Engineered Fill to consider the loading requirements for permanent structures. (D). Working platform designs and construction will need to consider compressibility of the underlying strata. (D). Rigid inclusion design will need to consider downdrag/negative skin friction and overarching effect between rigid inclusions associated with highly compressible materials. (D).			
6	Differential Settlement	Due to the variability of the Tidal Flat Deposits any formed earthworks and any shallow foundations could experience differential settlement across the length of the earthwork/shallow foundation structure and between the platform and structures.	3	4	12	Cause damage to drainage and structures, rendering them unsuitable for function/unsafe.	An assessment of settlement for the substation platform should be undertaken and a requirement for ground improvement at the site is likely. (CL) Drainage design may need to be flexible to allow for settlement and long-term maintenance if in areas where ground improvement not proposed (D). Ground improvement for structures is proposed. (CL)	2	4	8
7	Extensive Organic materials present on site	Limitation on ground improvement methodology due to presence of organics.	3	4	12	Potential of additional costs associated with	Ground Improvement optioneering has been be undertaken to understand	2	4	8

Item	Hazard	Risk	P	I	R	Consequence	Mitigation	P	I	R
		Potential for additional swelling of treated ground if soil stabilisation is utilised as a ground improvement technique.				fewer options of ground improvement. Swelling leading to damage to foundations/structures during lifetime of proposed substation.	which options are most suitable for the site. (CL) A ground improvement specialist has been consulted to understand risk from ground conditions identified and to understand if soil stabilisation would result in expansion. Trials for this would be required. (CL).			
8	Aggressive Ground Conditions	Gypsum present in underlying rock. Gypsum can lead to more aggressive concrete conditions. Peat can also be acidic which can lead to more aggressive concrete conditions.	3	4	12	Aggressive ground conditions may attack concrete foundations. Degraded concrete will require replacing incurring costs.	Received BRE tests for shallow natural materials indicate DS-4. High concrete classification required for concrete within shallow Tidal Flat Deposits. (D) Received BRE test for made ground indicates DS-3/AC-2. Made ground was not encountered in the footprint of the substation where load bearing structures are present therefore its unlikely concrete will come into contact with this material. (D)	2	4	8
9	Collapse of formed excavations.	Excavations may collapse due to very soft materials and groundwater present at shallow depths	3	4	12	Excavations at shallow depths are unlikely to remain stable during construction unless suitably benched/shored.	Vigilant to signs of instability during any excavation. Temporary support/benching may need to be considered for excavations > 1.0m bgl (CO). De-watering of excavations will be required during construction. (CO).	2	4	8
10	Surface Water & Shallow Groundwater	During the GI surface water was often present and groundwater was typically encountered at shallow depths during boring & excavation.	3	4	12	Higher groundwater level could lead to foundation failure if not	Appropriate groundwater level to be used within the design of foundations (D)	2	4	8

Item	Hazard	Risk	P	I	R	Consequence	Mitigation	P	I	R
						considered in the design.	Design of earthworks and finish ground level to consider surface water at the site (D)			
11	Uncertainty in ground water regime	Due to limited installations due to artesian conditions the long-term groundwater regime across the site could be different to that identified.	3	4	12	Higher groundwater level than that observed could lead to foundation failure.	Appropriate groundwater level namely surface level is to be used within geotechnical design. (D)	2	4	8
12	Artesian Water	Water pressure resulting in challenging rigid inclusion or sheet pile flood wall installation including for potential of washout of fines material and concrete.	3	4	12	Challenging installation could lead to increased programme/costs and potentially a need to change foundation solution.	Rigid inclusion and sheet pile flood wall installation should be agreed with an appropriate specialist (CO, CI)	2	4	8
13	Buried services	Encountering/striking buried services during works.	3	3	9	Services will need to be identified and diverted prior to construction. Safety of site personnel.	Service drawings for the site should be reviewed to identify the location of known services less than 3 months old at the time of works starting. A buried service survey should be obtained in line with PAS 128. Suitable offset from buried services (CL, CO).	2	3	6
14	CBR of material for pavement design.	GI has identified that the CBR values at the site are highly variable. For areas where pavements/roads are proposed then additional design to account for lower CBR values will be required.	3	3	9	Lower CBR value could result in having to carry out extensive excavations to achieve a suitable subgrade CBR. This can lead to increase costs and potential delays to programme.	Geogrid to be incorporated into design to minimise required excavations (D). Road design to account for specific CBR tests undertaken at locations based on the proposed road. (D) Verification CBR testing to be undertaken during construction (CO). Roads will require regular maintenance or a floating road system due to	2	3	6

Item	Hazard	Risk	P	I	R	Consequence	Mitigation	P	I	R
							settlement of TFD unless Ground improvement undertaken across the whole area. (D)			
15	Materials with high moisture contents	High moisture content resulting in lower CBR values within materials.	3	3	9	Lower CBR value could result in having to carry out extensive excavations to achieve a suitable subgrade CBR. This can lead to increase costs and potential delays to programme.	Geogrid to be incorporated into design to minimise required excavations (D). Verification CBR testing to be undertaken during construction (CO).	2	3	6
16	Material Re-use	Material present on site at shallow depths are unsuitable for re-use as earthworks for engineering purposes. Material very wet of optimum moisture content.	3	3	9	No cut & fill is proposed as part of the earthworks, however, some reduced level excavation will be required to develop the piling platform. Any excavated material may need to be disposed off site leading to increased costs. Significant costs/time associated with treatment of in situ material for re-use.	Preparation of a peat management plan to ensure any peat is retained on site. Re-use of cohesive materials could be considered for new and reinstated ditches. (CL). Design to minimise further excavation, therefore limiting the requirement of re-use of materials (D).	2	3	6
17	Ground gas included depleted oxygen risk.	Ground gas monitoring restricted due to the presence of shallow groundwater and artesian conditions.	4	3	12	Impact to health of future site users.	Installation of CS-2 gas protection measures.	2	3	6

Item	Hazard	Risk	P	I	R	Consequence	Mitigation	P	I	R
		Characteristic Situation 2 adopted via risk assessment.				Unconfirmed protection classification. Impact to design.				
18	Hazardous Classification of soil in area of TP115 0.2m bgl	Area of impacted ground unconfirmed. Lateral extent unknown.	4	3	12	Elevated disposal costs associated with extended area.	Delineation of extent of TPH concentrations as part of site enabling works. Waste management documentation should be produced setting out necessary materials handling, excavation, segregation and disposal process. Watching brief to be maintained for visual and olfactory evidence of contamination during construction works. Where identified contact to be made with a suitably qualified specialist (CO)	2	3	6

9. Engineering Discussion

9.1. Materials Reuse

The topography of the site recorded a ground level between 2.95m to 3.67mAOD during the Geotechnics GI. It is understood that the ground level will be reduced by 1.0m below the existing ground level to facilitate the construction of the working platform, with a proposed finished substation level of 4.15mAOD anticipated. It should be noted that the materials present at excavatable depths comprise the cohesive Tidal Flat deposits and peat, these materials are not suitable for use as an engineering material due to their high compressibility and organic content.

9.2. Substation Platform

Development of the substation the site level will require consideration of high groundwater levels and a 1,000-year flood event (4.7mAOD). The perimeter of the substation platform will be formed using a flood wall, the height of which is currently understood to be 5.3mAOD. At the time of writing this report detailed design of the flood wall was in progress and will be reported separately following the completion of additional ground investigation works, anticipated to be October 2025.

All fill constituting the substation platform will be imported engineered fill. Any increase in ground level will lead to an increase in effective stress on the soils present at the site. The materials at shallow depths comprise soft cohesive Tidal Flat Deposits and Peat, which are highly compressible materials, therefore excessive settlement from the placement of any engineering fill is likely. However, the compressibility and consolidation behaviour of Peat is distinctly different from mineral soils as it experiences high initial rates of primary consolidation and secondary consolidation following the dissipation of pore pressures. Secondary compression of Peat can continue for long periods and can be difficult to quantify.

A ground improvement options report (Ref [42]) was prepared to evaluate the viability of several ground improvement options. The results of which were presented within a matrix. The most viable in terms of suitability, constructability, cost, risk, and environmental impact was the use of rigid inclusions and a load distribution mattress. Following the selection of the most appropriate solution a ground improvement performance specification (Ref [43]) based upon the requirements of National Grid Technical Guidance Note 318 (Ref [44]) was prepared and provided to the Ground Improvement Specialists. At the time of preparing this report Expanded Piling are undertaking the design of rigid inclusions within the superficial deposits and Tailor Engineering are designing the load distribution mattress.

BakerHicks is responsible for the design of the platform above the load distribution mattress and have prepared an Earthworks Specification (Ref [45]) for that element of the works.

9.3. Foundations

9.3.1. Shallow Foundations

As discussed in Section 9.2 others are designing a ground improvement scheme to meet the requirements of National Grid Guidance Note 318 (Ref [44]). They are responsible for the design of this aspect which comprises rigid inclusions and a load distribution mattress. This design is based upon a BakerHicks performance specification which includes the structural loading from the proposed buildings and infrastructure. BakerHicks are responsible for the substation platform design above the load distribution mattress. This shall be constructed using Selected Granular Fill that has been engineered in accordance with the earthworks specification and the structures shall be founded within this fill. Slag material shall not be used in the construction of the platform of load distribution mattress due to the risk of swelling.

9.4. Excavations

Minor excavations are likely as part of the formation preparation. As discussed in section 9.1 significant excavations as part of a cut/fill balance are unlikely due to the existing ground level being lower than the

proposed finished level. As discussed in Section 9.2 ground improvement is recommended to be explored. If ground improvement is utilised at the site, then some shallow foundations may be used for minor structures depending on final loads. These foundations will require excavations where temporary stability measures are likely to be needed. Conventional plant should be suitable for excavating within cohesive Tidal Flat Deposits and the peat. Due to the shallow groundwater and surface water present it is likely that pumping of excavations will be required.

9.5. Surface Water Drainage

Three soakaway tests in accordance with BRE Special Digest 365 (Ref [24]) were attempted were not completed due to the high groundwater levels encountered at the site. Use of a groundwater level infiltration drainage system is not recommended at the site. However, alternative Sustainable Drainage Systems (SuDS) such as an attenuation system should be considered.

Alternatively, surface water should be managed and discharged by another means such as connection to sewer system or treated to an acceptable water quality and discharged to an existing nearby surface water feature subject to discharge consents. Flood assessments as part of the latter are not considered herein.

9.6. Groundwater

During the GI groundwater was typically encountered at surface or shallow depths associated with the Tidal Flat Deposits at the site, this level is likely influenced by the location of the site being on a low-lying marsh/grassland area. 1no. installation was placed within this material and all of the monitoring visits to date are showing groundwater level at the surface.

Groundwater was also encountered at depth associated with the granular Glacial Till deposits. Artesian water was also encountered at depth associated with the granular Glacial Till deposits present at the site. Out of 7no. strikes within this material 3no. were artesian rising to between -0.12m and -0.46m (above ground level). 1no. rising head test was undertaken in this material which returned a permeability of 9.52×10^{-4} m/s. The artesian water should be considered within the detailed design phase as it will need to be considered due to flood risks and it could result in uplift of the foundations. In situ permeability testing showed that the granular glacial deposits have high permeability, whereas the cohesive glacial deposits and cohesive tidal flat deposits have very low permeability.

9.7. Coal Mining

As mentioned earlier in the report and detailed within the Coal Mining Risk Assessment (Ref. [14]) there is a low risk of historical coal mining activities on this proposed development. As recommended in the CMRA a limited amount of deeper GI was undertaken: BH107 & BH109 to 50m to investigate the presence of any unrecorded workings beneath the site. There was no observable evidence of any worked seams. BH109 within the proposed Margam Substation boundary recorded intact coal at a depth of 42.55m bgl and a thickness of 0.5m. Given the thickness of this seam it is unlikely to have been worked. Furthermore, if the intact coal represented a pillar within a working, at the depth recorded this seam has 28.25m of rock cover which is sufficient to mitigate effects of surface subsidence based on encountered seam thickness and guidance in CIRIA C758D (Ref. [15]). In summary, worked coal seams are unlikely to be present within an influencing depth of the proposed development.

9.8. External areas, highways and pavements

Hard surfacing is expected for new platform, pavement areas and pedestrian footpaths to the structures and new car parking areas. According to CD 225 (Ref. [46]) the minimum permitted CBR value is 3%. Any CBR value less than 2.5% at subgrade is not considered to be of a suitable subgrade strength to support a pavement foundation and the subgrade requires improvement.

From the Dynamic Cone Penetrometer (DCP) tests undertaken at the site, the CBR values computed for the top of the cohesive Tidal Flat Deposits were assessed to range between 0.3% and 16.1%, which is highly variable. Higher values could be attributed to the gravel content of the material.

Therefore, for new hardstanding surface areas, in-situ CBR testing is required on the subbase at formation level. The Contractor should test to ensure the CBR of the subgrade is at least 2.5%, or as per pavement design prior to construction. As discussed in Section 9.2, ground improvement is required as part of the substation formation. As such, road formation could be undertaken using conventional methods with little material.

10. Summary and Recommendations

10.1. Geotechnical

Based on the discussion above, the following recommendations are provided:

- A ground improvement scheme shall take place to provide a substation platform that will meet the requirements of National Grid Technical Guidance Note 318 (Ref [44]). This is being designed by Expanded Piling (Rigid Inclusions) and Tailor Engineering (Load Distribution Mattress).
- Buried Concrete Design will need to consider the aggressive Tidal Flat Deposits at the site. BRE assessment demonstrated that concrete placed in these materials need to be of a sulphate class of DS-4 and an ACEC class of AC-5.
- The groundwater observations during the GI and the subsequent monitoring suggests that the design groundwater level should be at surface level. The detailed design should also account for uplift due to the artesian water within the granular Glacial Till deposits.
- Materials at shallow depth are unlikely to be excavated in significant quantities according to proposed cut/fill plan for the substation platform. However, these materials at shallow depth are not suitable to be re-used as engineered materials due to their high compressibility and high organic content.
- Once the ground improvement has been constructed the remainder of the substation platform shall be constructed using Selected Granular Fill, with foundations placed within this fill. Care will need to be taken to not damage any reinforcement with the load distribution mattress.
- Infiltration SuDS techniques, based on three soakaway tests attempted on site and high groundwater levels encountered during the ground investigation, are not suitable for the site.

10.2. Geo-environmental

The revised conceptual site model has identified a potential risk to future site users associated with ground gas migration. The source of ground gas is considered to be associated with organic soils. Industry guidance (Ref [40]) associates the risk with organic soils to necessitate the adoption of Characteristic Situation 2 protection measures. Subsequent site-specific risk assessment may allow revision in the gas classification, however this would represent a separate package of work.

In order to address the risk posed from ground gas a Remediation Strategy outlining the gas protection for the site will be required. Gas protection measures associated with a CS-2 classification require two levels of gas protective measures from the below.

The following options are suggested as methods of ground gas protection; a) reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with minimum 1200g DPM b) block and beam or precast concrete slab and minimum 2000g DPM/or reinforced gas membrane c) possibly under-floor venting or pressurisation in combination with a) and b) depending on use. All joints and penetrations sealed. The classification should be completed in line with BS8485 Table 5 and 6 (Ref [38]).

A validation Report will then be required to validate the ground gas protection measures have been implemented in line with the Remediation Strategy. It is recommended that the Remediation Strategy is submitted and agreed with the Local Authority prior to any implementation of protection measures.

Due to potential depleted oxygen levels, access to trenches should be limited, or with the use of specific gas alarms. Control measures should be determined by the Principal Contractor.

It is advisable that all gas protection measures are agreed with the regulator prior to adoption in construction.

Soil Reuse

The human health risk assessment presented above has confirmed that soils comply with the adopted screening criteria, however localised Total Petroleum Hydrocarbon concentration has been identified associated within TP115 0.2m bgl. Whilst values fall below the adopted screening criteria the concentration are associated with an Elevated Classification for disposal off site. The extent of concentrations are unknown such that the immediate area should be confirmed to allow confirmation of disposal costs and avoid mixing of soils during excavation works. This may be completed as part of site enabling works, with waste management documentation produced to set out necessary materials handling, excavation, segregation and disposal process.

Once extents of elevated concentrations are known, the re-use of site won material within the site development or at an off-site location should be possible where compliant with methodology set out within the CL:AIRE Definition of Waste: Development Industry Code of Practice (Ref [41]). As such, where material reuse is proposed under the framework, it will be necessary for the Contractor to produce a Materials Management Plan, clearly and accurately detailing the proposed materials management scheme for the site. This should be completed before any materials have been excavated.

Watching Brief

There are inherent uncertainties associated with environmental sampling of heterogeneous subsurface materials and the potential for encountering unidentified / unforeseen contamination persists. Therefore, it is recommended that a watching brief is maintained for potential contamination during groundwork at the site.

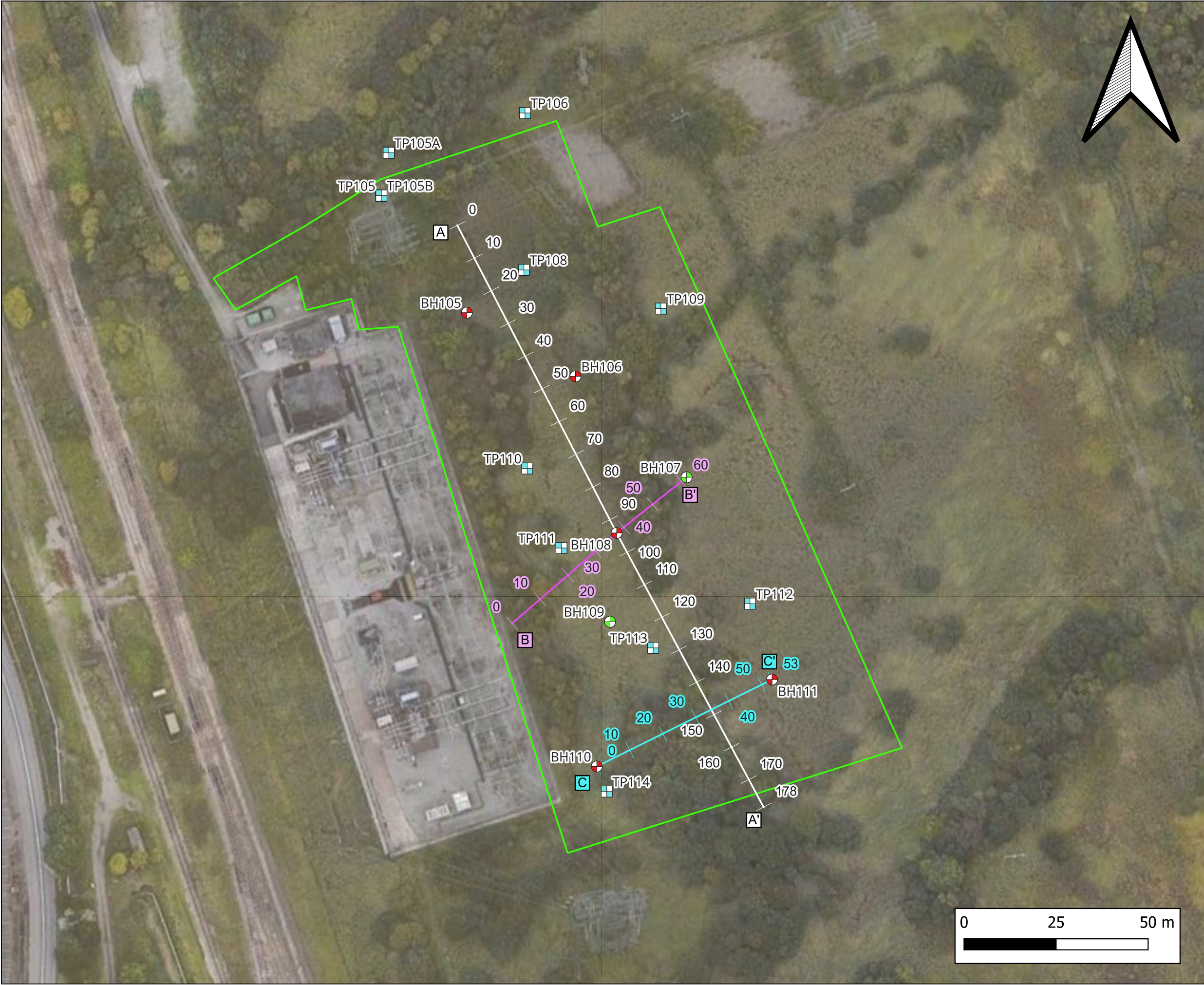
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Appendix D. Geological Cross Sections



REFERENCE SHOULD BE MADE TO
GEOLOGICAL CROSS SECTIONS:
CROSS SECTION A-A'
CROSS SECTION B-B'
CROSS SECTION C-C'

- LEGEND**
- MARGAM SUBSTATION BOUNDARY
 - COMPLETED GROUND INVESTIGATION
 - CABLE PERCUSSIVE BOREHOLE
 - CABLE PERCUSSIVE & RC BOREHOLE
 - MACHINE EXCAVATED TRIAL PIT
 - GEOLOGICAL CROSS SECTIONS (Ch. M)
 - SECTION A - A'
 - SECTION B - B'
 - SECTION C - C'

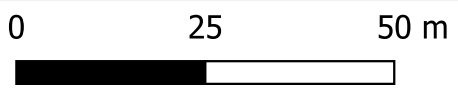


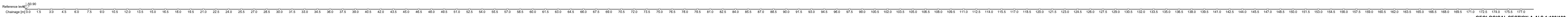
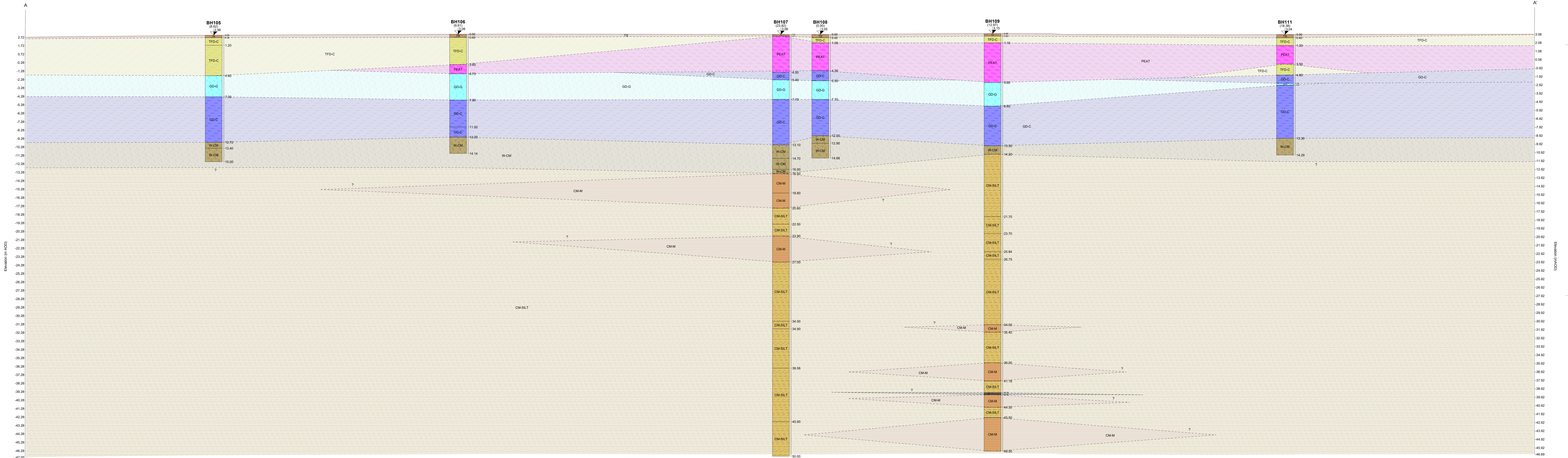
Client			
LAING O' ROURKE			
Project			
MARGAM SUBSTATION - LoR			
Title			
MARGAM SUBSTATION CROSS SECTION LOCATION PLAN			
Scale	Drawn	Checked	Approved
	JT	VB	PDH
1:1000 (A3)	Date	Date	Date
	20/12/24	20/12/24	15/01/25



BakerHicks
One Warwick Technology Park
Gatton Road
Warwick
CV34 6PL
UK
Tel: 01926 821700
www.bakerhicks.com

Project Number	Drawing Number	Rev
30004595	APPENDIX D	P01





Legend

Topsoil/Topsoil-Cover	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty
Peat	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty
Gravelly Drift - Gravel	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty
Gravelly Drift - Clay	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty
Washed Clay Material	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty
Clayey Material - Medium	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty
Clayey Material - Silty	Gravelly Drift - Gravel	Gravelly Drift - Clay	Washed Clay Material	Clayey Material - Medium	Clayey Material - Silty

Project Information

Project number: 30004555

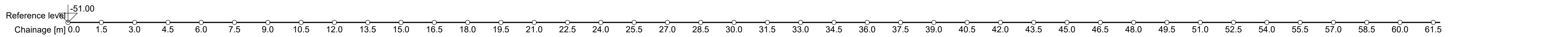
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Document name: Morgan Substation GPR

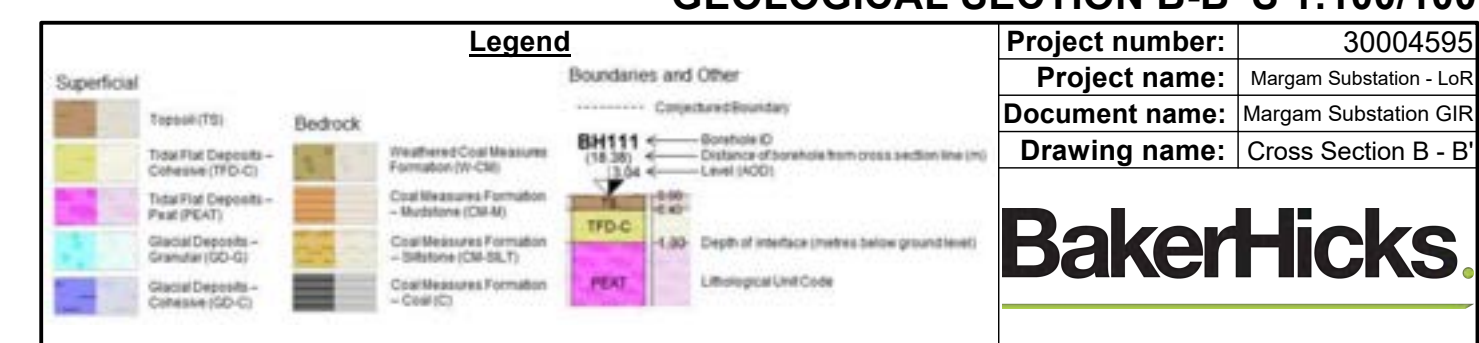
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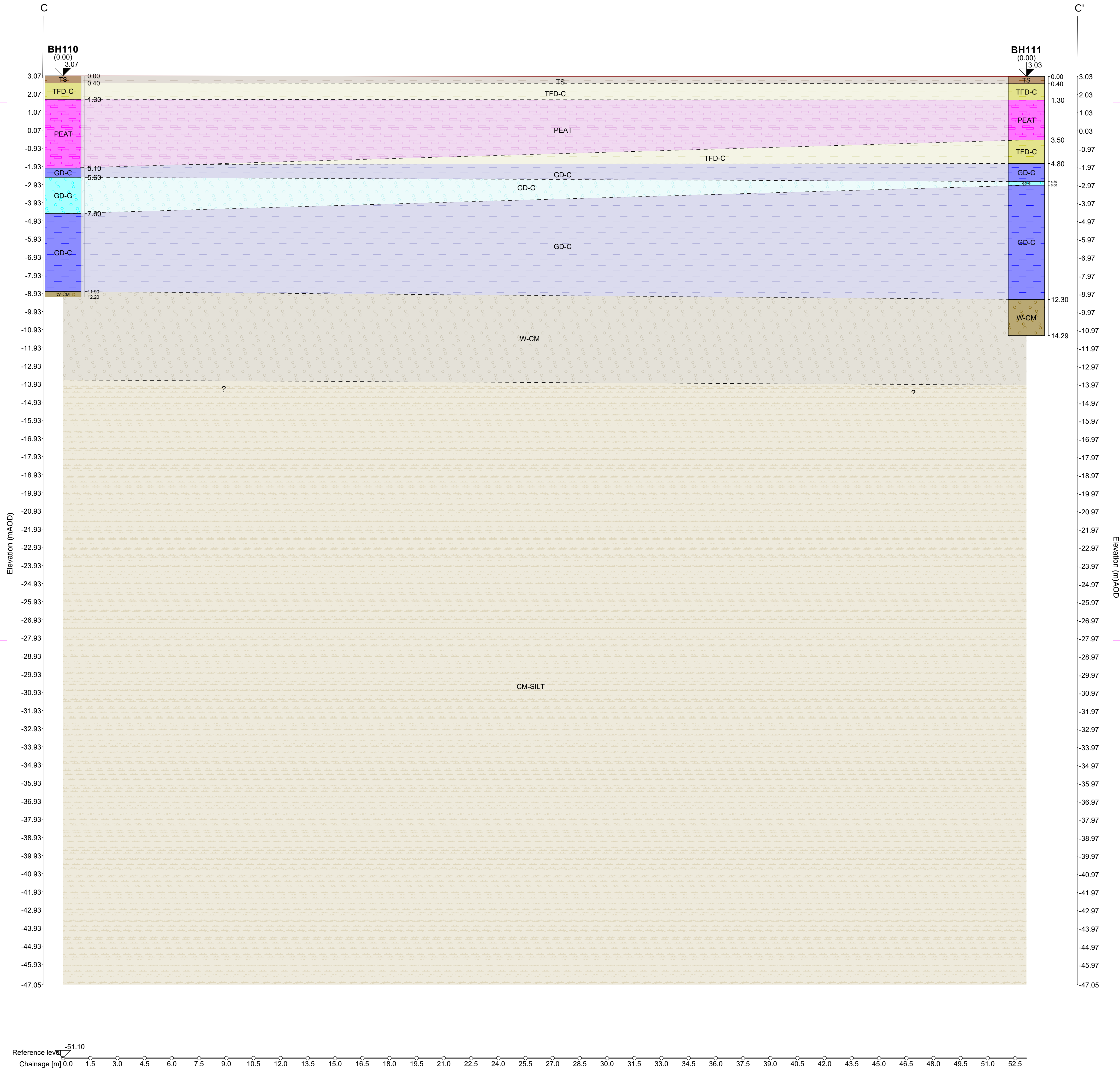
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GEOLOGICAL SECTION B-B' S 1:100/100





Reference level

Chainage [m]

0.0

1.5

3.0

4.5

6.0

7.5

9.0

10.5

12.0

13.5

15.0

16.5

18.0

19.5

21.0

22.5

24.0

25.5

27.0

28.5

30.0

31.5

33.0

34.5

36.0

37.5

39.0

40.5

42.0

43.5

45.0

46.5

48.0

49.5

51.0

52.5

Superficial

Topsoil (TS)

Total Flat Deposits - Cohesive (TFD-C)

Total Flat Deposits - Peat (PEAT)

Glacial Deposits - Siltystone (GD-SLT)

Glacial Deposits - Cohesive (GD-C)

Bedrock

Weathered Coal Measures Formation (W-CM)

Coal Measures Formation - Mudstone (CM-M)

Coal Measures Formation - Siltystone (CM-SLT)

Coal Measures Formation - Coal (C)

Legend

Boundaries and Other

BH111

Distance of sample from cross section line (m)

Level (ASD)

Depth of interface (metres below ground)

Geological Unit Code

Project number:

30004595

Project name:

Margam Substation - LoR

Document name:

Margam Substation GIR

Drawing name:

Cross Section C - C'

BakerHicks

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- York +44 (0)1904 231858

Europe

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